DOE/EA-1113-A

MITIGATION ACTION PLAN FOR THE PROTECTION OF THE NATURAL AREA ON PARCEL ED-1

April 2003

U.S. Department of Energy
Oak Ridge Operations
Oak Ridge, Tennessee

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FOR THE PROTECTION OF THE
NATURAL AREA ON PARCEL ED-1

Date Issued—April 2003

U.S. Department of Energy
Oak Ridge Operations

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ACRONYMS

BMAP	Biological Monitoring and Abatement Program
CFR	*Code of Federal Regulations*
CROET	Community Reuse Organization of East Tennessee
DOE	U.S. Department of Energy
EA	Environmental Assessment
EFPC	East Fork Poplar Creek
EIS	Environmental Impact Statement
EPT	Ephemeroptera + Plecoptera + Trichoptera
FONSI	Finding of No Significant Impact
MAP	Mitigation Action Plan
NEPA	National Environmental Policy Act of 1969
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ROW	right-of-way
SR	State Route
T&E	threatened and endangered
TDOT	Tennessee Department of Transportation
TWRA	Tennessee Wildlife Resources Agency

1. INTRODUCTION

In January 1996, the U.S. Department of Energy (DOE) executed a lease for the approximate 957-acre Parcel ED-1 to the Community Reuse Organization of East Tennessee (CROET) to develop an industrial/business park (now known as the Horizon Center). The lease subsequently became effective in April 1998. This action was preceded by an Environmental Assessment (EA) (DOE 1996a) resulting in a finding of no significant impact (FONSI), conditioned upon the implementation of mitigation and monitoring of the sensitive areas of Parcel ED-1. According to DOE's National Environmental Policy Act of 1969 (NEPA) regulations [10 *Code of Federal Regulations* (*CFR*) 1021.322], a FONSI shall include "*any commitments to mitigations that are essential to render the impacts of the proposed action not significant, beyond those mitigations that are integral elements of the proposed action, and a reference to the Mitigation Action Plan prepared under 10 CFR 1021.331*."

In accordance with the terms of the FONSI and as specified by 10 *CFR* 1021.331, a Mitigation Action Plan (MAP) was issued that described measures to be implemented to monitor and mitigate potentially significant adverse impacts that could occur from development on Parcel ED-1 (DOE 1996b). The MAP accomplished this by excluding areas of Parcel ED-1 from disturbance and development and requiring that surveys and monitoring be conducted on development areas prior to disturbance (pre-development) and during industrial operations (post-development). The objectives of these measures included: (1) protection of wildlife habitat, plant communities, threatened and endangered (T&E) species, water resources, wetlands, and historic and archaeological resources; (2) maintenance of habitat connections to reduce the ecological effects of fragmentation; (3) pre- and post-construction assessment of natural succession and impacts of development on natural communities and populations using data collected during monitoring; and (4) identification of additional mitigation, as needed, to remediate the actual adverse effects of development.

MAP objectives (1) and (2) were met by the establishment of a "Natural Area" (formerly referred to as the "Exclusion Area") within which no development (e.g., construction of habitable structures) should occur except for areas of unavoidable encroachment (i.e., roads and utilities). To meet objective (3), Oak Ridge National Laboratory (ORNL) initiated ecological surveys in June 1996. These surveys comprised the majority of the pre-development monitoring of the areas excluded from industrial development. MAP objective (4), to date, has focused on preventing the introduction of exotic species into Parcel ED-1. CROET in its Covenants, Conditions, and Restrictions for the parcel has provided a list with native plant recommendations and a list of invasive exotic pest plants in Tennessee. Owners and occupants are encouraged to use plants from the native list for landscaping and to avoid the plants on the other list. Additional mitigation (i.e., restoration and/or compensation) has not been necessary, since no damages or adverse impacts have occurred that would require such measures.

A requirement of the MAP is the preparation of Annual Reports by DOE to document baseline conditions in the Natural Area; survey data and monitoring status; and planning, construction, and operational phases of the development. The 1997 Annual Report (DOE 1977) documented pre-development conditions to use as a baseline, and it established monitoring sites for future use. At the request of DOE, CROET assumed responsibility for the preparation of future annual reports. CROET in turn contracted with Lockwood Greene Engineers, Inc. to complete the monitoring requirements of the MAP. The 1998 Annual Report (DOE 1998) described progress toward meeting objectives of the MAP during the site development planning and early construction phases. Specifically, the report addressed development alternatives, pre-development surveys, and monitoring plans during early construction.

A plan was developed to meet economic development goals while adhering to the commitments in the FONSI and the MAP. A main goal of the development plan was to maximize developable acreage while preserving the important ecological and scenic features of the parcel (Fig. 1.1). Planning and layout of the site also relied heavily on several ecological studies designed to locate T&E species and to minimize the impact to stream and floodplain crossings. The objective of the 1999 and 2000 Annual Reports (DOE 1999 and 2000) was to meet the NEPA commitment to monitor specified environmental resources during early site construction and operation as development matured.

CROET awarded construction contracts for clearing right-of-ways (ROWs) for roads, utilities, borrow areas, and a sub-leased parcel soon after the lease was activated in the summer of 1998. Permits were obtained for construction of culverts and bridges in late 1998. Construction of the culverts and bridges began in late 1998 and continued to completion in 1999. Permits were obtained for sewer and water distribution systems in 1999. Construction began on the first sub-leased parcel (the Theragenics Center) in the summer of 1999. Grading and the foundation for the Theragenics building were completed by the last of November, and erection of steel began in December. A major emphasis in 2000 was directed toward completing road construction, installing underground utilities in the road ROWs, and completing construction on the Theragenics Center.

Three new sites were cleared and prepared for construction in 2000 (Fig. 1.2). The first of these was an addition to the Communications Center and fiber-optics hub facility located on about 1 acre near the middle of Parcel ED-1. A second was the erection of a new telecommunications tower on approximately 0.25 acre of the northwest sector of the parcel. The third involved clearing and grading of approximately 15 acres along the Oak Ridge Turnpike [State Route (SR) 95] adjacent to the west entrance to the parcel. Activities since 2000 have primarily been to clear brush and remove dead pines (due to the Southern pine beetle infestation) at the corner properties where the park roads intersect with the Oak Ridge Turnpike, and to conduct other routine maintenance activities.

On February 21, 2002, CROET submitted a proposal to DOE requesting the title transfer of Parcel ED-1. Following that on August 19, 2002, CROET submitted a supplement to its proposal requesting that the developable portion of Parcel ED-1 be transferred to Horizon Center LLC, a subsidiary of CROET. DOE initiated activities in March to meet the requirements necessary to support the title transfer, including reviewing and updating the NEPA documentation.

One of the first actions by DOE after receipt of CROET's proposal for the transfer of Parcel ED-1 was to convene a DOE peer review of the existing MAP. The Peer Review Team met in Oak Ridge on March 12–14, 2002. The goals of the Team were the following:

1. Assess the monitoring data collected to date and establish if the requirements of the MAP have been met.

2. Determine if changes to the MAP are warranted due to the intended future use of Parcel ED-1 and plans for activities adjacent to the parcel [e.g., Tennessee Department of Transportation (TDOT) expansion of SR 95].

3. Clarify the future monitoring and mitigation requirements, including defining when mitigation is necessary.

4. Identify when the next review of the MAP should be conducted.

DOE completed an EA Addendum (DOE/EA-1113-A) for the transfer of title of Parcel ED-1 to CROET. After review of the analysis, DOE issued a FONSI for the proposed action, conditioned upon the implementation of mitigation and monitoring to continue to protect environmental resources.

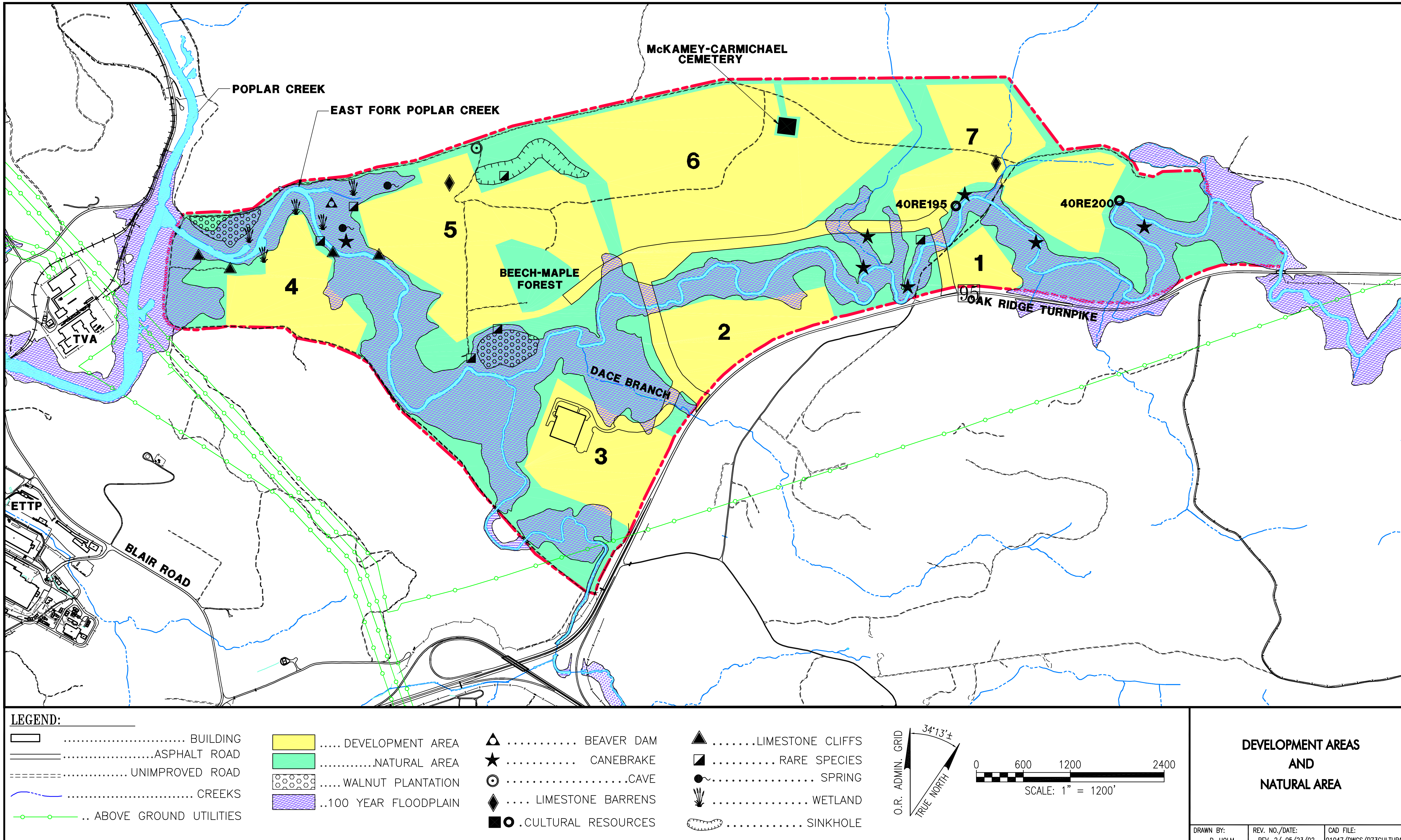

Fig. 1.1. Parcel ED-1 Development Areas and Natural Area

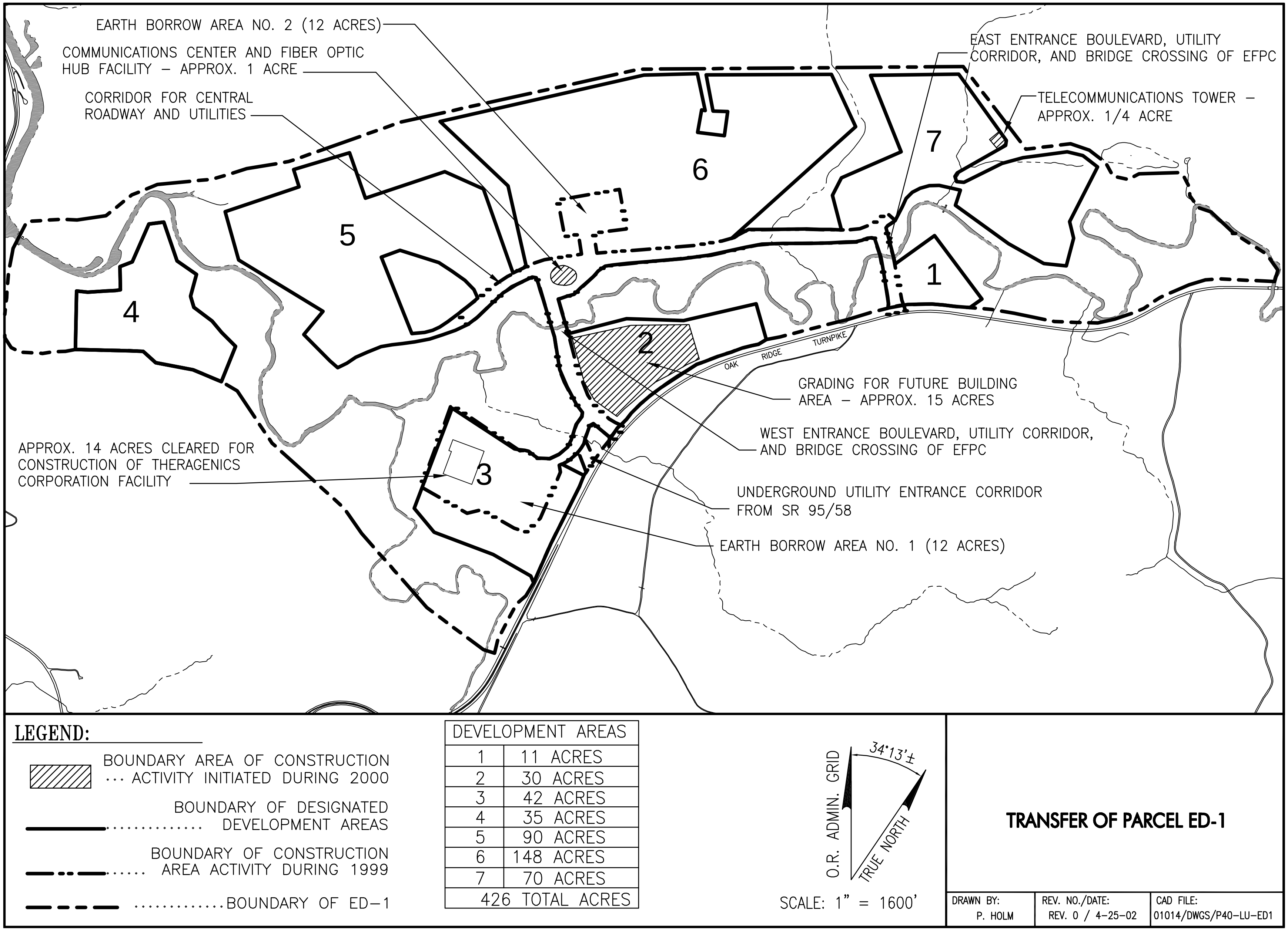

Fig. 1.2. Parcel ED-1 Construction Activities for 1999 and 2000.

The requirement that Horizon Center LLC monitor the Natural Area and perform mitigation of any of the sensitive resources within the Natural Area, if necessary, will be in the lease. If Horizon Center LLC fails to abide by the provisions of the lease within the specified cure period, then DOE and Horizon Center LLC may resolve the dispute subject to the dispute clause in the lease. Ultimately, DOE has the right of termination if the requirements are not met.

This MAP incorporates the recommendations of the DOE peer review. It also contains a summary and quantitative evaluation of monitoring data collected between 1996-2000, and monitoring requirements and mitigation measures for ecological and cultural resources. The objectives of these measures include: (1) to assess whether the integrity of the sensitive resources within the Natural Area is being maintained and to identify encroachments and any necessary maintenance or potential mitigation; (2) continuation of monitoring to detect and characterize changes from the baseline (pre-development) conditions and to determine if significant adverse impacts are occurring; and (3) mitigation, as needed, to help avoid, minimize, or remediate any adverse impacts to the sensitive areas. The MAP also contains a section describing review and reporting requirements.

Copies of this MAP may be reviewed at, and annual reports may be obtained from, the address listed below.

U.S. Department of Energy
Information Center
475 Oak Ridge Turnpike
Oak Ridge, Tennessee 37830
Phone: (865) 241-4780 or 1-800-382-6938

2. DATA SUMMARY

Based on a recommendation from the peer review, DOE undertook a technical review of the existing data that have been collected on Parcel ED-1 to evaluate whether any significant adverse impacts have occurred and to provide the basis for the changes recommended in this revised MAP.

2.1 SUMMARY OF MONITORING ACTIVITIES

The previous MAP specified that post-development monitoring was to be conducted in the Natural Area and possibly off-site (e.g., north of the site) as development progressed. The monitoring plan included quarterly (seasonal) surveys by plant and wildlife ecologists in the Natural Area; triennial vegetation and wetland surveys; and annual monitoring of game populations (wild turkey, waterfowl, and deer), birds in the terrestrial ecosystem, and fish and benthic macroinvertebrates in the aquatic ecosystem. Monitoring surveys of birds, fish, and benthic macroinvertebrates were to be conducted annually. After a period of three years, the suitability of less frequent monitoring was to be re-evaluated.

The following table presents a summary of the ecological monitoring conducted by ORNL and Lockwood Greene between 1996 and 2000 (Table 2.1). The information and data were obtained from the DOE Annual Reports (1997–2000).

Table 2.1. Summary of ecological monitoring on Parcel ED-1

Monitoring Type	Year					Comments
	1996	1997	1998	1999	2000	
Terrestrial Vegetation	x	x	x	--	--	T&E, 5 sensitive communities, 5 common habitat-strata types
Birds	x	x	--	x	x	2 seasons, 2 routes
Fish	x	x	x	x	x	2 seasons, 4 stations
Benthic macroinvertebrates	x	x	x	x	x	2 seasons, 4 stations
Bats	--	x	--	--	--	47 net nights over 27 sites
Lepidoptera	--	x	--	--	--	3 sites
Mammals, Reptiles	--	x	--	--	--	16 sites, 6 habitat types
Amphibians	--	x	--	x	--	5 sites for 6 months
Game	--	x[a]	--	--	--	deer, turkey, duck, bobwhite

Source = Parcel ED-1 Annual Monitoring Reports (DOE 1997-2000).
[a] Data for animals harvested during hunting.
x = data collected.
-- = data not collected.
T&E = Threatened and endangered.

2.1.1 Terrestrial Ecosystem

2.1.1.1 Vegetation

Terrestrial vegetation for portions of Parcel ED-1 was quantitatively surveyed in 1996, 1997, and 1998.

Numbers of individual sensitive, rare, and/or protected plant species of different types were enumerated between June and September in 1996 and in May of 1997. The beech-maple forest (three sites) was surveyed in June 1997, resulting in estimates of abundance, basal area, density, and percent exotics. Two sections of the limestone cliffs on the parcel were qualitatively surveyed in July 1996 resulting in lists of native species and exotics. One site in the limestone barren was surveyed in July 1996; red cedars and other woody species of different sizes were enumerated, percent woody cover was estimated, and woody and exotic species were listed. Lists of dominant species in four Parcel ED-1 wetlands were made in July 1996. The percent cane cover was estimated for a canebrake site.

Ground cover, seedling/sapling/shrub habitat, floodplain forest, and upland forest were surveyed at numerous sites in May and June 1996. The number of species; total cover and percent exotics in ground cover; and total density of seedlings, saplings, and shrubs and percent exotics were measured at 18 sites. The number of individuals per species and basal area were measured at 12 floodplain forest sites and six upland forest sites. In 1998, lists of species were compiled for 12 areas to be cleared for road construction.

2.1.1.2 Birds

Birds were quantitatively surveyed in two seasons (spring and fall) along two monitoring routes (perimeter and floodplain) in each of the years 1996, 1997, 1999, and 2000. In each year, surveys were conducted identically using the point-count method (Hamel et. al. 1996) with 19 points along the periphery route and 25 points along the floodplain route. Additional counts were made of the number of species and individuals at two bridge sites located on the floodplain route.

2.1.1.3 Game species

DOE has monitored deer and wild turkey populations on the Oak Ridge Reservation (ORR), including Parcel ED-1, during controlled hunts managed by DOE and the Tennessee Wildlife Resources Agency (TWRA) since 1985. Hunting was discontinued on Parcel ED-1 starting in 1997, and no harvest records for the parcel are available since that time. No attempts have been made to quantify populations of whitetail deer, wild turkey, wood duck, mallard duck, and northern bobwhite. Only casual observations of these species have been reported.

Deer have continued to be observed on Parcel ED-1 and are common. They move over most of the parcel during non-work hours. Tracks of buck, doe, and young have been observed in roadways, clearings, and around water sources (DOE 2000).

Prior to the development of Parcel ED-1, the area provided prime habitat for wild turkey. The secondary succession resulting from pine beetle destruction of timber and the subsequent timbering operations reduced the area of prime habitat on the parcel. Construction activities during 1998–2000 further reduced the amount of habitat. Even with the reduction in habitat, wild turkey continue to be observed throughout the year, including several broods of young poults observed during spring 2000 (DOE 2000).

From 1993 to 1997, TWRA and ORNL staff conducted surveys from canoes in June for wood ducks on the lower reach of East Fork Poplar Creek (EFPC). Adults with young were observed in 3 out of 5 years, and lone adults were observed in each of the 5 years. While no canoe surveys were conducted in 1998 or 1999, lone adults were heard and seen on EFPC. Three breeding pairs were identified in spring 2000. Two groups of wood ducks were flushed during early December 2000, indicating they use EFPC as a winter habitat (DOE 2000).

Mallard ducks were not reported as occurring on Parcel ED-1 in the baseline census (DOE 1997) or the first census following the beginning of construction. However, in the spring census of 2000, breeding mallard ducks were reported on EFPC. They have also been heard and seen on other occasions throughout the year and, therefore, are considered a permanent resident on the parcel (DOE 2000).

Northern bobwhite is considered a declining species on the ORR (DOE 2000). This has also been true for the bobwhite population on Parcel ED-1. However, they were seen in the upland and floodplain habitats in the spring and summer of 2000. The increased open area and edge along with secondary succession may provide habitat that supports the recovery of this game bird on the parcel (DOE 2000).

2.1.1.4 Other species

Bats, moths, and butterflies (Lepidoptera), mammals, reptiles, and amphibians were quantitatively surveyed as part of the pre-development monitoring for T&E species, as specified by the MAP. Bats netted in June and July 1997 were identified to species and sexed. Two to four nets were set each night at a total of 27 sites over 16 nights (47 net nights total). Lepidopterans (butterflies, moths, and skippers) and their host plants were counted at three sites during 16 dates between June 24 and July 22 in 1997. The number of individuals and species of small mammals, reptiles, and amphibians observed or trapped during surveys of 16 sites distributed among six habitat types (bottomland forest, beech-maple forest, oak-hickory-ash limestone woodland, clearcut areas, limestone cliff area, and hardwood plantations) between March and July 1997 were recorded. The relative intensity of calling activity of different frog species was quantified once per month between March and August at five sites in 1997 and again in 1999. No T&E species were identified by those surveys.

2.1.2 Aquatic Ecosystem

Fish and benthic macroinvertebrates were surveyed in two seasons (spring and fall) at several stations within Parcel ED-1 in each of the years 1996 through 2000. Data collected by the Biological Monitoring and Abatement Program (BMAP) between 1984 and 2000 from stations on or near Parcel ED-1 supplemented the other data. Fish were sampled by electroshocking, and the identity, length, and weight of collected fish were recorded in one or more years. Benthics were sampled using a surber sampler and/or kick net with three or four replicates per site resulting in counts of individuals of different taxa, including chironomids and Ephemeroptera + Plecoptera + Trichoptera (EPT) taxa.

2.2 QUANTITATIVE EVALUATION OF MONITORING DATA

Quantitative monitoring data for terrestrial and aquatic ecosystems at Parcel ED-1 indicate few trends and no significant adverse impacts. The results of the trends analyses for birds, benthic macroinvertebrates, and fish monitoring data are presented in Appendix A and summarized below. Power tables presented in Appendix B can be used to estimate the statistical power of the data to detect trends. The results of the data evaluation and power tables were used to recommend revisions to the MAP and to meet the requirements of the FONSI (see Sect. 3.1.2).

2.2.1 Terrestrial Ecosystem

Trends in the vegetation data could not be evaluated because data were not collected in similar times of the year in more than 2 years at any site.

As specified in the MAP, birds were quantitatively surveyed in two seasons (spring and fall), along two routes (perimeter and floodplain), in each of the years 1996, 1997, 1999, and 2000 using identical survey methods. No significant trends ($Pr > 0.05$ that slope = 0) were detected in the total bird abundance and species richness, abundance of birds of conservation concern, and abundance of birds on the Partners in Flight National Watch List. The large increase in bird abundance and richness in 1997 is not explained by changes in survey methodology or personnel. ORNL personnel conducted both the 1996 and 1997 surveys using identical methods, and subsequent survey by Lockwood Greene used the same methods and level of effort.

Because there are data for two or fewer years, trends and impacts for bats, moths, and butterflies (Lepidoptera), mammals, reptiles, and amphibians could not be evaluated.

2.2.2 Aquatic Ecosystem

Fish and benthic macroinvertebrates were surveyed in two seasons (spring and fall) at several stations within Parcel ED-1 in each of the years 1996 through 2000 and between 1984 and 2000 from BMAP stations on or near Parcel ED-1. No significant trends were detected in benthic macroinvertebrate abundance, taxonomic richness, percent EPT, and average percent chironomids at Parcel ED-1 stations EFK2.3, EFK5.1, BCK0.1, and DBK0.3 (Appendix A). A significant trend of increasing total abundance was detected in the fall at BCK3.3, upstream of Parcel ED-1, between 1984 through 2000. Significant increasing trends in taxonomic richness and percent EPT were detected in the fall at stations EFK6.3 on Parcel ED-1 prior to construction (1985 through 1995) and in both spring and fall samples at BCK 3.3 (1984 through 2000). A significant trend of decreasing percent chironomids in the spring was detected at Dace Branch at Parcel ED-1 (DBK0.3) between 1997 and 2000. No significant trends were detected in fish density, taxonomic richness, percent generalist feeders, percent piscivores, and percent tolerant species at Parcel ED-1 stations EFK2.3, EFK5.1, BCK0.1, and DBK0.3 (Appendix A). Between 1988 and

2000, significant trends of increasing taxonomic richness and decreasing percent generalist feeders in both the spring and fall, and decreasing percent piscivores in the fall, were detected in data from BCK3.3 upstream of Parcel ED-1. A significant trend of increasing number of fish taxa in the fall season was detected at station EFK6.3 on Parcel ED-1 (1985 through 1999). The significant trends at individual stations, except decreasing piscivores at BCK3.3, are generally considered to be indicative of improving conditions. While increasing taxonomic richness at EFK6.3 in and of itself is not definitively indicative of improving conditions, the coincident increase in percent EPT indicates the direction of change in the community was generally positive.

3. MONITORING AND MITIGATION

3.1 ECOLOGICAL RESOURCES

3.1.1 Inspections

Horizon Center LLC will be responsible for conducting on-site inspections of the sensitive areas (Fig. 1.1) within the Natural Area boundary on Parcel ED-1 three times each year: December–January (before the ideal construction time), April–June (during flowering, nesting, and spring migrations), and September–October (following the prime construction period). The following areas will be inspected:

- perimeter boundary of the Natural Area,
- cave,
- sinkholes,
- canebrakes,
- springs,
- wetlands,
- rare species locations,
- east and west corridors,
- walnut plantations,
- beech-maple forest, and
- EFPC and Dace Branch buffer zones.

These inspections will be conducted to assess whether the integrity of the sensitive areas within the Natural Area is being maintained and to identify encroachments and any necessary maintenance or potential mitigation. The inspections will be conducted by qualified wildlife and plant biologists/ecologists who will observe and record the following:

- General condition of the vegetation within each area. Major changes or perturbations should be recorded (e.g., stressed vegetation or encroachment by exotic/invasive plant species).

- Observations of any wildlife.

- General condition of streams and springs (e.g., fish kills, excessive turbidity or sedimentation, oil sheens, foam, etc.).

During construction activities, Horizon Center LLC, or its designee, will conduct more frequent inspections of areas being disturbed to ensure that minimal encroachment of the Natural Area boundary is occurring and that no significant adverse impacts occur. These inspections will be in addition to any other inspections that may take place by city or state officials (i.e., codes or other regulatory enforcement).

3.1.2 Monitoring

Monitoring was specified in the MAP (DOE 1996b) to detect and characterize changes from the baseline (pre-development) conditions. Sampling methods, intensity, and frequency specify the data quality objectives. The sampling method specified in the MAP (DOE 1996b) and natural variability at Parcel ED-1 determined the statistical confidence (alpha) and power to detect changes and trends of different magnitude. Sampling intensity and frequency should be reconsidered periodically based on the observed variability and potential to detect ecologically significant trends.

3.1.2.1 Birds

Given the power of current bird surveys to detect decreases in bird abundance and species richness, monitoring of birds will continue for at least 3 more years with the first of those 3 years to include the 2002 data already collected. Annual sampling conducted over this period of time (1996 through 2004) should detect a decrease of 5% per year in bird abundance and species richness, if it occurs, with a probability between 0.33 and 0.65 for total abundance and a probability greater than 0.65 for species richness. The bird surveys will be conducted in the spring, preferably during the months of May and June, which is the prime nesting season for most birds. The standard procedure that has been used for the previous surveys will continue to be used including the use of the two established routes (floodplain and periphery). This will ensure that the future data collected can be statistically compared with the historical data. The need for further monitoring can be evaluated using these data.

3.1.2.2 Amphibians

The peer review recommended that a baseline be established for amphibians in the planned wildlife corridors located on Parcel ED-1 (Fig. 1.1). CROET performed a survey of amphibians in 2002 (June-July). Methods used were consistent with those used during the pre-development surveys conducted in 1997 by ORNL (DOE 1997a) and included pitfall trap arrays and transects with and without drift fences, artificial covers, and active searches. All species either trapped or observed were recorded and the results will be presented in the next Annual Report. Additional monitoring of amphibians can be conducted by recording observations made during the on-site inspections, which include inspections of the wildlife corridors.

3.1.2.3 Benthic macroinvertebrates

Monitoring of benthic macroinvertebrates will continue. Benthic macroinvertebrates are likely more sensitive than fish to the potential impacts associated with development (e.g., siltation and water quality impairment) and, thus, will serve to indicate changes in the aquatic ecosystem. Benthic macroinvertebrates will be sampled once per year, in the spring. Monitoring will occur at upstream station EFK 6.3 and downstream station EFK 2.3. In accordance with the MAP (DOE 1996b) and recommendation of the peer review, the frequency of sampling is reduced to once per year because major adverse changes were not detected after 3 years of monitoring. A greater abundance and diversity of benthic macroinvertebrates and EPT taxa are expected in the spring than the fall. The method for conducting the benthic sampling will be the same as what has been used previously. The resulting data will allow analysis for trends in total abundance, taxonomic richness, percent EPT, and percent chironomids. Annual monitoring in the spring season will continue for at least 3 more years with the first of those 3 years to include the 2002 data already collected. Over 8 years, annual sampling should be able to detect a decrease of 5% per year in total abundance, richness, and percent EPT with a probability between 0.23 and 0.65. After a total of 8 years, the need for further monitoring can be re-evaluated using these data.

3.1.2.4 Fish

As recommended by the peer review, monitoring of the fish community in Dace Branch will continue. This is because it contains a reproducing population of the Tennessee dace, which is listed by the state as “Deemed In Need of Management.”

Site preparation and construction activities during 1998 and 1999 resulted in exposing large areas of soil in the vicinity of Dace Branch. Two major storm events in the early spring of 1999 caused runoff to overrun the silt fence allowing sediments to enter Dace Branch, which may have adversely impacted the Tennessee dace. In fall 1998, the number of Tennessee dace was 19, a number higher than previously recorded (DOE 1998). In spring 1999, four individuals were found (DOE 1999). In October 1999, there were only two individuals, and none was found during the spring 2000 sampling (DOE 2000). A population of Tennessee dace was found upstream of the normal sampling location (DBK 0.3). This population was located upstream from influences of construction and downstream from culverts under the Oak Ridge Turnpike. These fish may repopulate the downstream reaches of Dace Branch as the stream recovers from the 1999 siltation events. Continued sampling will confirm recovery.

The Dace Branch will be sampled annually during the spring (April-May) for at least 3 more years (8 years total). The 2002 data already collected will be counted as the first of the 3 years. Annual sampling over 8 years should be able to detect a decrease of 5% per year in species richness with a probability greater than 0.88. After a total of 8 years, the need for further monitoring can be evaluated using these data.

3.1.3 Mitigation

The peer review recommended that the MAP clarify future mitigation requirements, including defining when mitigation is necessary. The Council on Environmental Quality *Regulations For Implementing The Procedural Provisions Of The National Environmental Policy Act* (40 *CFR* 1500-1508) defines mitigation as follows:

- Avoiding the impact altogether by not taking a certain action or parts of an action.
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- Compensating for the impact by replacing or providing substitute resources or environments.

DOE and CROET have already mitigated potential impacts to certain sensitive resources found on Parcel ED-1 by establishing the Natural Area. This action has served to avoid, minimize, reduce, and in many cases eliminate impacts to the sensitive resources found on the parcel. Horizon Center LLC will continue to be responsible for the preservation and maintenance of the integrity of the Natural Area, including the sensitive resources it contains.

Horizon Center LLC also will continue to provide mitigation by continuing to recommend that native plants be used for all revegetation of disturbed areas and landscaping of developed areas. These species should be native to the Ridge and Valley Province and consistent with local community types (see the recommendation in the Horizon Center Covenants, Conditions, and Restrictions document). Lawn areas will also be kept to a minimum to the extent possible.

To help control erosion and sedimentation during land disturbing activities, best management practices like those described in the *Tennessee Erosion & Sediment Control Handbook* (TDEC 2002) will be used as appropriate. These best management practices can include vegetative practices (e.g., buffer zones and temporary vegetation), structural practices (e.g., silt fences, diversions, sediment basins) or a combination of both. In addition to the proper design and installation, any best management practices must also be properly maintained in order to effectively reduce erosion and sedimentation.

If, based on the tri-annual on-site inspections, it is determined that exotic/invasive plants (see Southeast Exotic Pest Plant Council http://www.exoticpestplantcouncil.org/) are encroaching into areas of sensitive plant communities [i.e., *Hydrastis canadensis* (goldenseal), *Cypripedium acaule* (pink lady-slipper), and *Panax quinquifolius* (ginseng)], Horizon Center LLC will make a good faith effort to eliminate the encroachment (a determination on the best method of removal will be made on a case-by-case basis). This maintenance will provide the mitigation needed to help reduce or eliminate potential impacts (i.e., degradation) to the sensitive plant communities.

Horizon Center LLC will be held responsible, under the terms of the Quitclaim deed and their lease, to ensure that they maintain the integrity of the Natural Area, and that they take appropriate measures to prevent significant adverse impacts to the sensitive resources within the Natural Area. Use of the Natural Area will be permitted as long as that use is non-intrusive and consistent with the natural environment (e.g., walking paths). Encroachment into the Natural Area for additional infrastructure development may be necessary and if so, it will be done in accordance with the appropriate regulations and the conditions specified in the lease. Construction of habitable structures within the Natural Area will be prohibited. Encroachment into the sensitive areas where federal or state-listed species are known to occur will be prohibited. If unanticipated impacts to the sensitive resources take place that could cause significant adverse impacts, especially those resources protected by law (e.g., wetlands, T&E species, and surface waters), Horizon Center LLC will be required to take mitigation measures, such as rehabilitation, restoration and/or compensation, as appropriate. Enforcement mechanisms are in the lease and the Quitclaim Deed in the event that Horizon Center LLC or any of its successors, transferees, or assigns fails to abide by their provisions. DOE will also be able to conduct mitigation within the Natural Area if it becomes necessary, since they will maintain ownership.

3.2 CULTURAL RESOURCES

Horizon Center LLC will be responsible for the continued protection of the McKamey-Carmichael cemetery and sites 40RE195 and 40RE200 (Fig. 1.1). Horizon Center LLC, or its designee, will conduct annual inspections of the perimeter of the McKamey-Carmichael cemetery and the 100-ft buffer zone around sites 40RE195 and 40RE200 to ensure that their integrity has not been compromised. Inspection results will be included in the Annual Reports.

If, during any development activities, an unanticipated discovery of cultural materials (e.g., human remains, pottery, bottles, weapon projectiles, and tools) or sites is made, all ground-disturbing activities in the vicinity of the discovery will be halted immediately. If the discovery is made on DOE-owned property then Horizon Center LLC will be responsible for immediately informing the DOE-Oak Ridge Operations Cultural Resources Management Coordinator. DOE will be responsible for contacting the Tennessee State Historic Preservation Office and the Eastern Band of Cherokee Indians Tribal Historic Preservation Office for completing consultation prior to any further disturbance of the discovery-site area. If on the other hand, the discovery is made on property where title has been transferred then the required consultations will be made by the property owner.

4. REVIEW AND REPORTING REQUIREMENTS

Prior to transferring title of the developable parcels, Horizon Center LLC will perform a review, using the information in the MAP and the Annual Reports, to determine if there is a potential for the property owner to significantly impact any of the sensitive resources found in the Natural Area. This review should occur prior to the following scenarios:

- A new occupant constructing on Parcel ED-1,
- A change to an existing operation that has the potential to adversely impact any sensitive resources contained within the Natural Area,
- A significant change to the habitat that is adjacent to Parcel ED-1 (e.g., TDOT expansion of SR 95),

The results of this review will be coordinated with the responsible DOE Program office. If there is the potential for a significant impact to a sensitive resource as determined by DOE or Horizon Center LLC, then it will be necessary to review the monitoring and mitigation requirements in the MAP to determine if changes are necessary. This MAP review will be conducted by DOE. Every effort will be made to conduct the MAP review in a timely manner. As a guideline, the review should take no more than 20 days to complete. The extent of the review will be based on the potential for impacts to sensitive resources. If additional time is required then this activity will be coordinated with the Horizon Center LLC to make sure that there is not an adverse impact to their schedule. At a minimum, the MAP should be reviewed once every 3 years to determine if modifications are necessary.

DOE will continue to publish Annual Reports on the implementation of the MAP. Copies of the annual reports will be placed in the DOE Information Center and a notice of availability will be made to the public.

5. REFERENCES

DOE (U.S. Department of Energy) 1996a. *Environmental Assessment – Lease of Parcel ED-1 of the Oak Ridge Reservation by the East Tennessee Economic Council,* DOE/EA-1113, April.

DOE 1996b. *Mitigation Action Plan – Lease of Parcel ED-1 of the Oak Ridge Reservation by the East Tennessee Economic Council,* DOE/EA-1113, April.

DOE 1997. *Annual Report – Implementation of Mitigation Action Plan for DOE/EA-1113: Lease of Parcel ED-1 of the Oak Ridge Reservation, Oak Ridge, Tennessee, Pre-Development Ecological Surveys,* DOE/EA-1113/MAP-97, November.

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DOE 1999. *Annual Report – Implementation of Mitigation Action Plan for DOE/EA-1113: Lease of Parcel ED-1 of the Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/EA-1113/MAP-99, December.

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Hamel, P.B., Smith, W.P., Twedt, D.J., Woehr, J.R., Morris, E., Hamilton, R.B., and Cooper, R.J., 1996. *A Land Manager's Guide to Point Counts of Birds in the Southeast,* Gen. Tech. Rep.

TDEC (Tennessee Department of Environment and Conservation) 2002. *Tennessee Erosion & Sediment Control Handbook: A Guide for Protection of State Waters through the use of Best Management Practices during Land Disturbing Activities*, available at http://www.state.tn.us/environment/wpc/sed_ero_controlhandbook/index.html. March.

6. GLOSSARY

Community Reuse Organization—A governmental or non-governmental organization that represents a community adversely affected by DOE work force restructuring, and that has the authority to enter into and fulfill the obligations of a DOE financial assistance agreement. For the Oak Ridge Operations office, CROET is this organization, and for Parcel ED-1 their subsidiary, Horizon Center LLC, is the transferee.

Environmental Assessment—A written environmental analysis that is prepared pursuant to NEPA to determine whether a federal action would significantly affect the environment and, thus require preparation of a more detailed Environmental Impact Statement (EIS).

Environmental Impact Statement—A document required of federal agencies by NEPA for major projects or legislative proposals significantly affecting the environment. A tool for decision-making, it describes the positive and negative effects of the undertaking and lists alternative actions.

Finding of No Significant Impact—A document prepared by a federal agency that presents the reasons why a proposed action would not have a significant impact on the environment and, thus would not require preparation of an EIS. A FONSI is based on the results of an EA.

Fragmentation—The disturbance or destruction of large contiguous areas of habitat into smaller, often isolated, portions or habitat patches.

Mitigation—Measures taken to reduce adverse impacts on the environment. According to 40 *CFR* 1508.20, mitigation includes: (1) avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of an action; or (5) compensating for an impact by replacing or providing substitute resources or environments.

Natural Area—That portion of Parcel ED-1 formerly referred to as the Exclusion Area. The Natural Area contains important ecological and scenic features of the parcel (e.g., cave, springs, limestone cliffs, wetlands, rare and sensitive species and habitat, wildlife corridors, floodplain and stream buffer for EFPC and Dace Branch, and cultural resources).

Post-development—Occurring during site or facility development and/or construction and during industrial operations.

Pre-development—Prior to any site disturbance or construction activities. Pre-development monitoring was completed in 1996 and the results are included in the Annual Report published in 1997.

Sensitive Resources—Important ecological, cultural, and scenic features located within the portion of Parcel ED-1 referred to as the Natural Area and protected by a variety of regulations. These resources are shown on Figure 1.1 and include a cave, sinkholes, canebrakes, springs, wetlands, rare species locations, east and west wildlife corridors, walnut plantations, beech-maple forest, EFPC and Dace Branch buffer zones, and the McKamey-Carmichael cemetery.

Tri-annual—Occurring or being done 3 times per year.

Triennial—Occurring or being done once every 3 years.

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APPENDIX A
ADDITIONAL DATA SUMMARY

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Bird Monitoring Data

Data Sources

Data were obtained from Lockwood Green Technologies and hand entry from the ED-1 MAP reports. Lockwood Green data were received as Excel spreadsheets. These data included bird population survey counts for the periphery and floodplain routes from 1996 to 1999, excluding 1998. Data were hand entered into Excel spreadsheets from the 2000 MAP report.

Data Processing

SAS data analysis software was used to summarize and graph the data. The total number of birds was summed across each location, year, season and sampling route (Table 1). The number of species identified was also calculated across each location, year, season and sampling route (Table 1). These data for each location, season, and route were plotted by year to allow for a visual examination of temporal trends in the data (Figures 1 to 4).

Summary statistics were calculated for the total number of birds and the number of species for each season and sampling route (Tables 3 and 4). The summary statistics include the total number of samples, mean, standard deviation, coefficient of variation, maximum, minimum, and the probability for normality test. The coefficient of variation (CV) is the standard deviation divided by the mean and taken as a percent. The CV is a measure of the variability of the measurement. The probability for normality test is the probability for the Shapiro-Wilk test for determining if the data are different from a normal distribution. Data with probability values less than 0.05 would be considered significantly different from normal.

A simple linear regression analysis was performed for total number of birds versus year and the total number of species versus year to look for a simple linear increase or decrease in the ecological measurements over time. The regression tables contain the parameter estimates for the slope, standard error, probability, R-square, and 95% lower (LCL) and upper (UCL) confidence limits on the slope. Probability values less than the alpha level chosen indicate a statistically significant slope and, therefore, a statistically significant trend. The R-square value indicates how well the linear regression fits the measurements. R-square values close to 1.0 indicate a very good fit. R-square values close to zero indicate a poor fit.

Plots, summary statistics, and regression analyses were also computed for two subsets of the bird species: birds of conservation concern and birds on the PIF National Watch List (Figures 5 to 12 and Tables 6 to 12).

References

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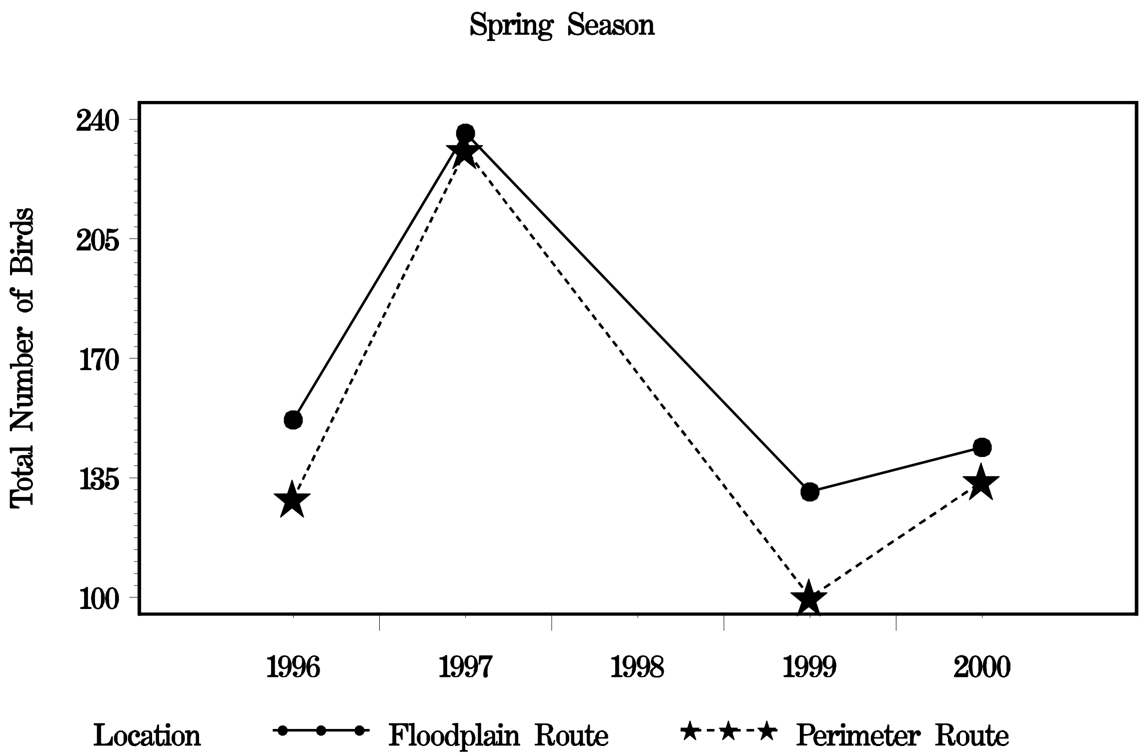

Figure 1. Number of birds counted at ED-1 during the Spring.

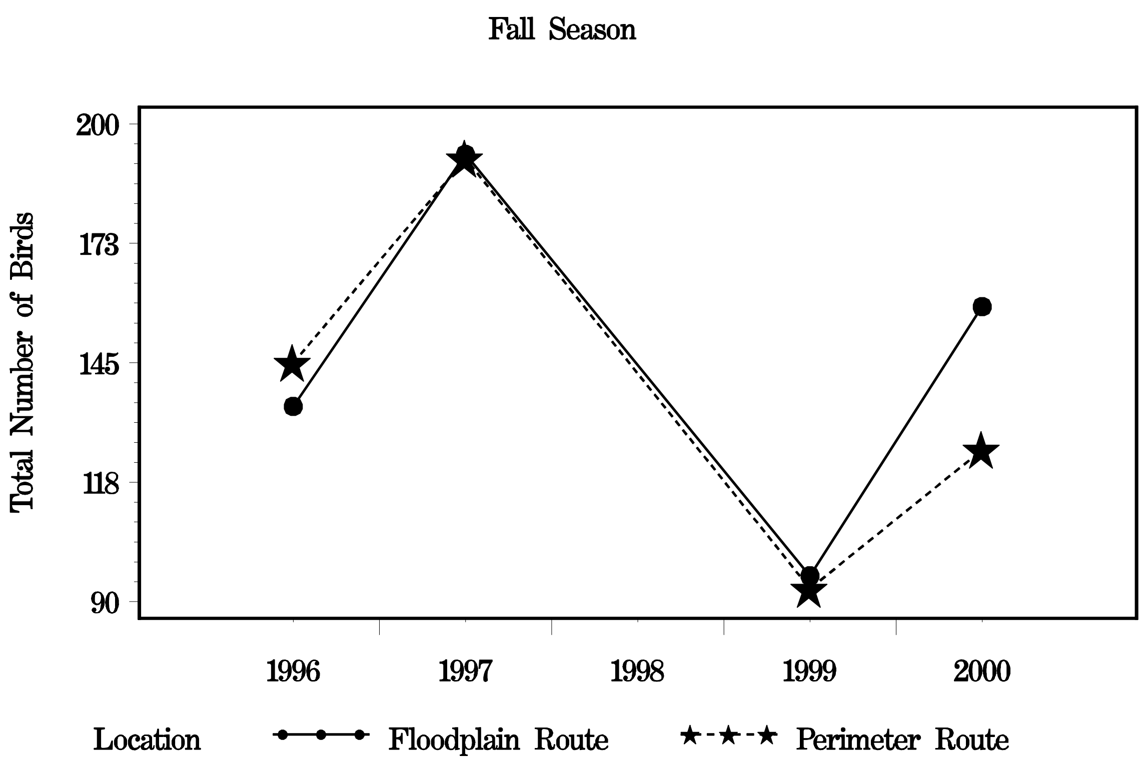

Figure 2. Number of birds counted at ED-1 during the Fall.

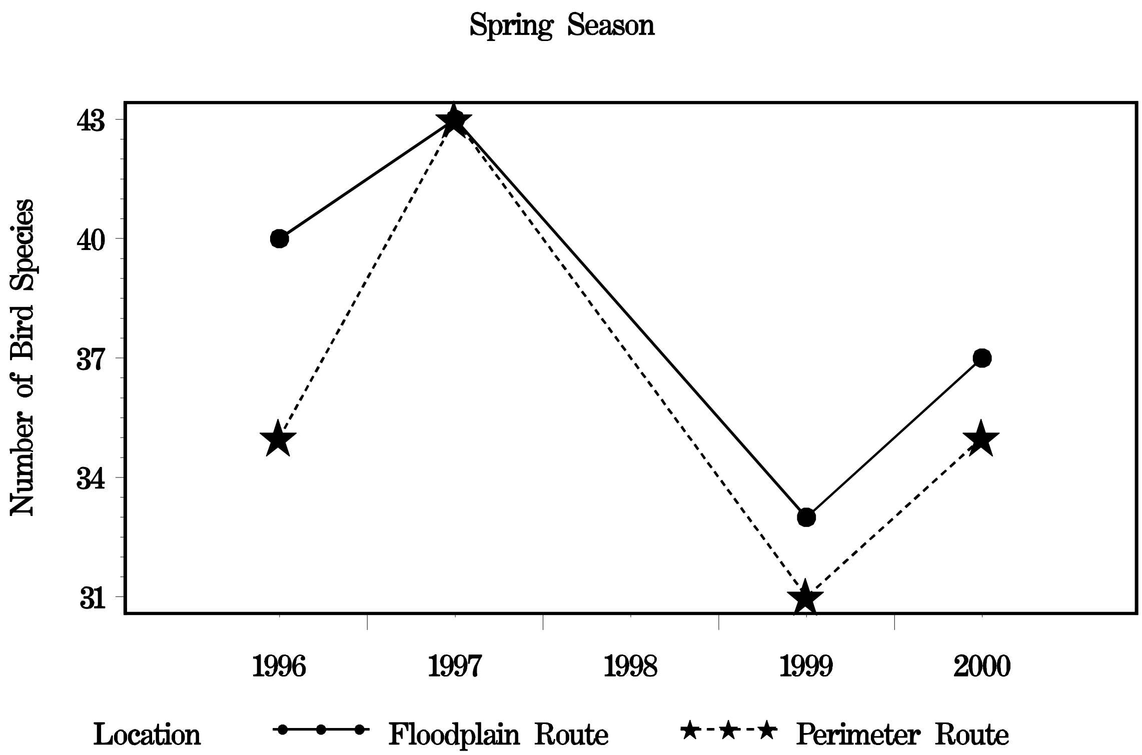

Figure 3. Number of bird species counted at ED-1 during the Spring.

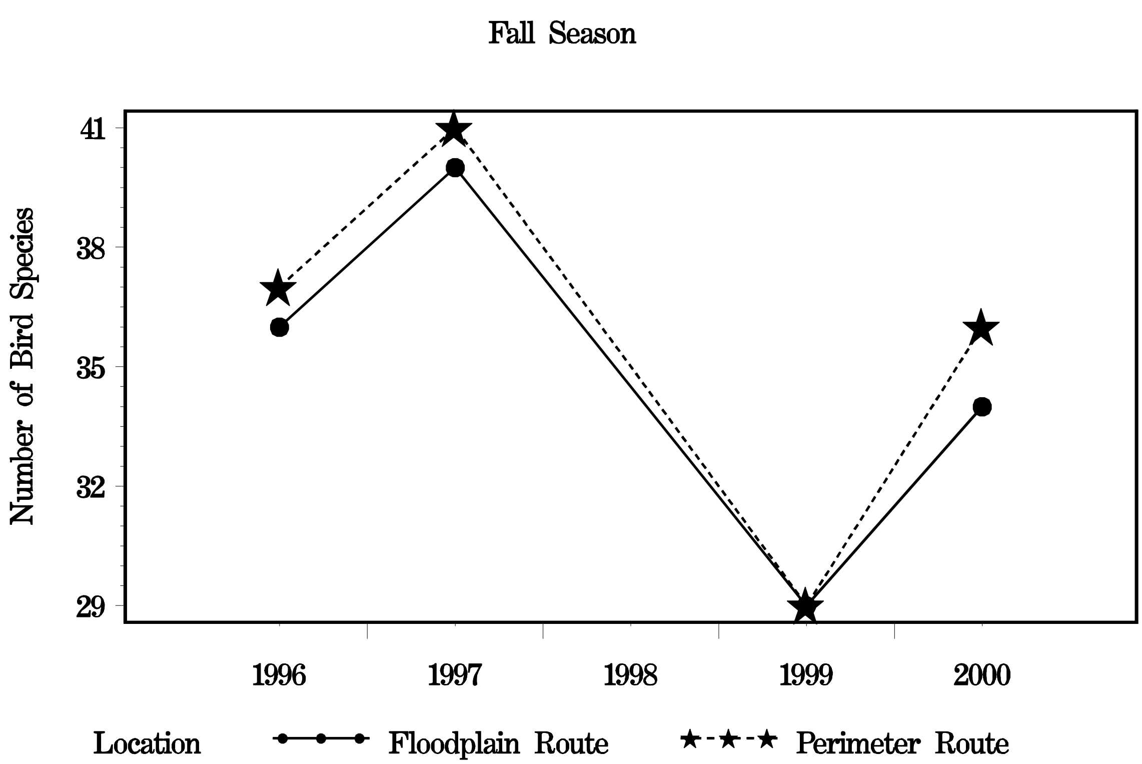

Figure 4 Number of bird species counted at ED-1 during the Fall.

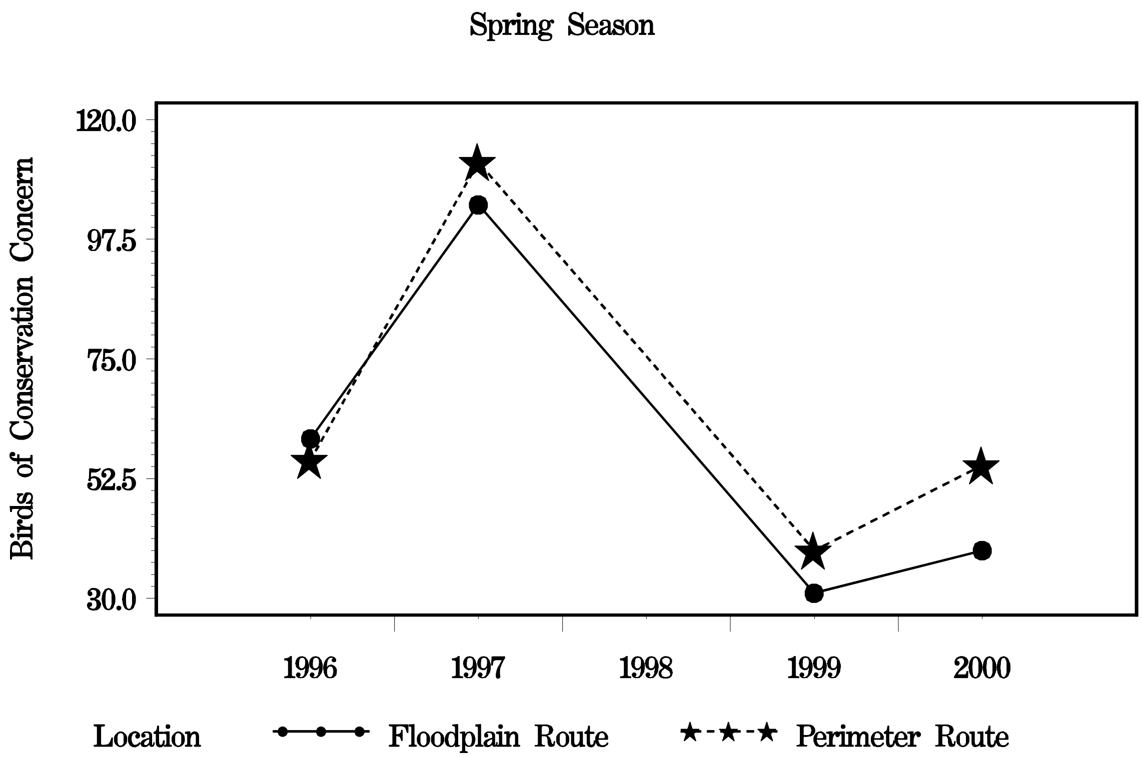

Figure 5. Number of birds counted of conservation concern at ED-1 in Spring.

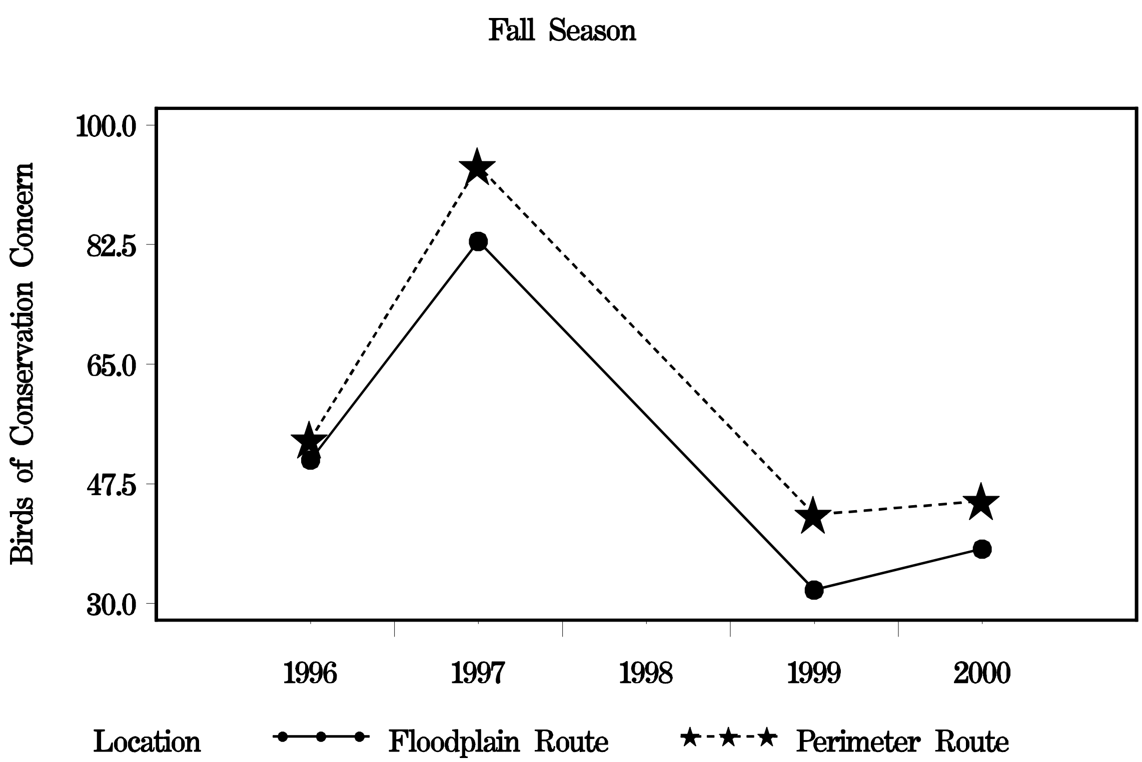

Figure 6. Number of birds counted of conservation concern at ED-1 in Fall.

Spring Season

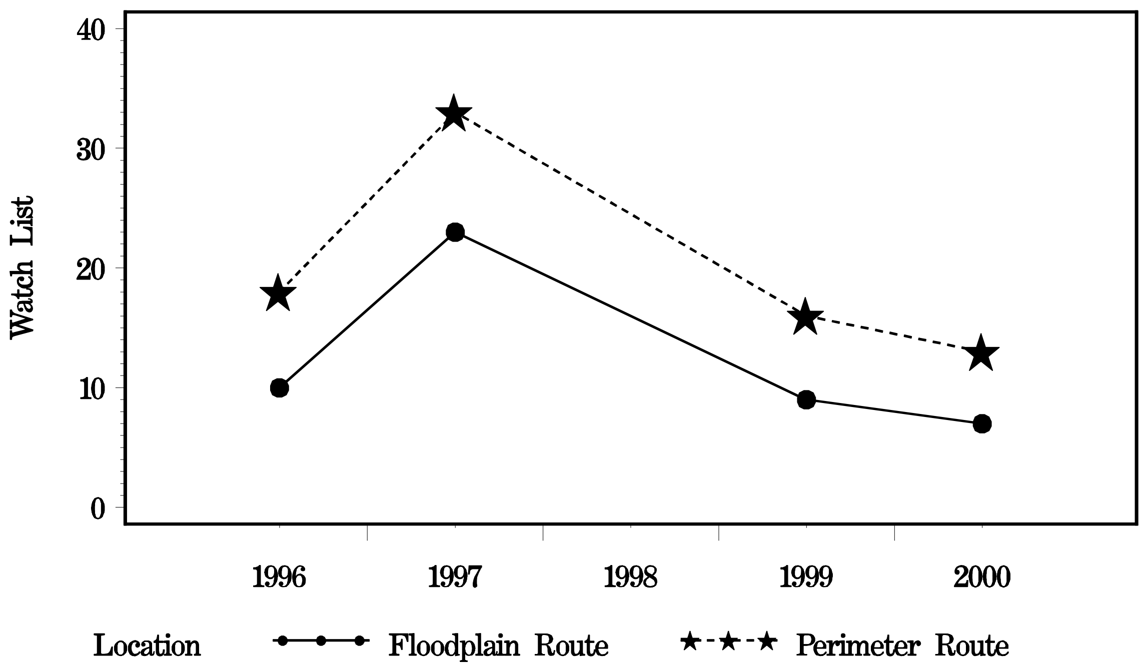

Figure 7. Number of birds counted on PIF Watch List at ED-1 in Spring.

Fall Season

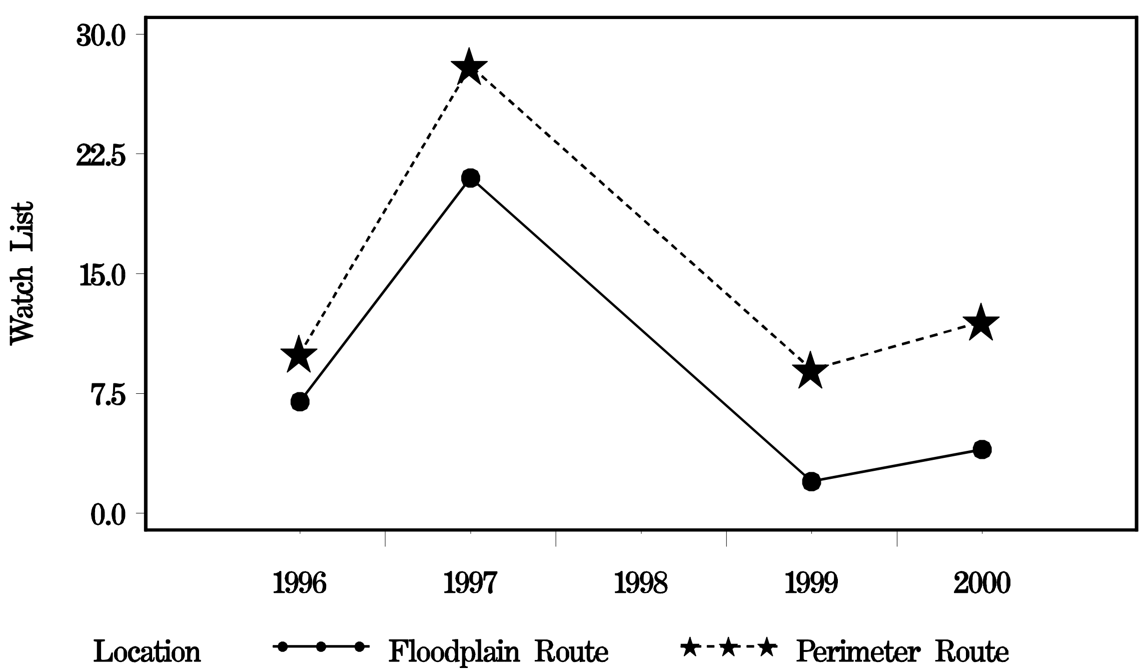

Figure 8. Number of birds counted on PIF Watch List at ED-1 in Fall.

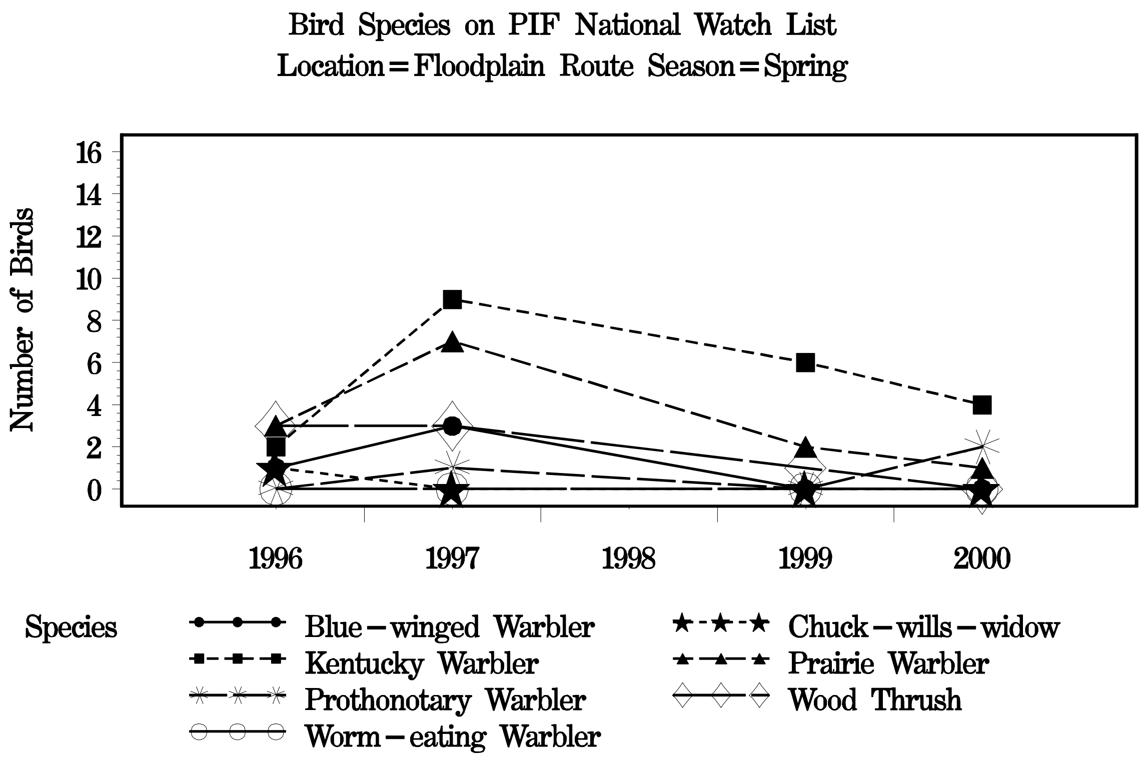

Figure 9. Number of birds counted on PIF Watch List at ED-1 in Spring by species on floodplain route.

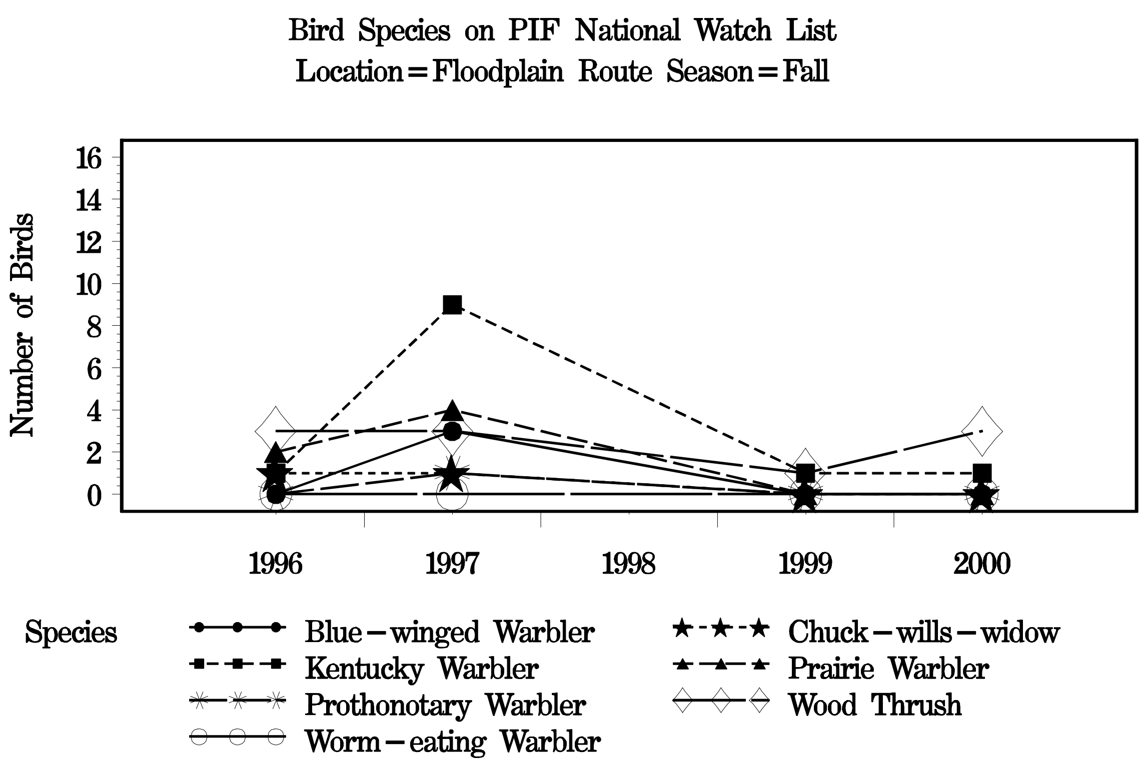

Figure 10. Number of birds counted on PIF Watch List at ED-1 in Fall by species on floodplain route.

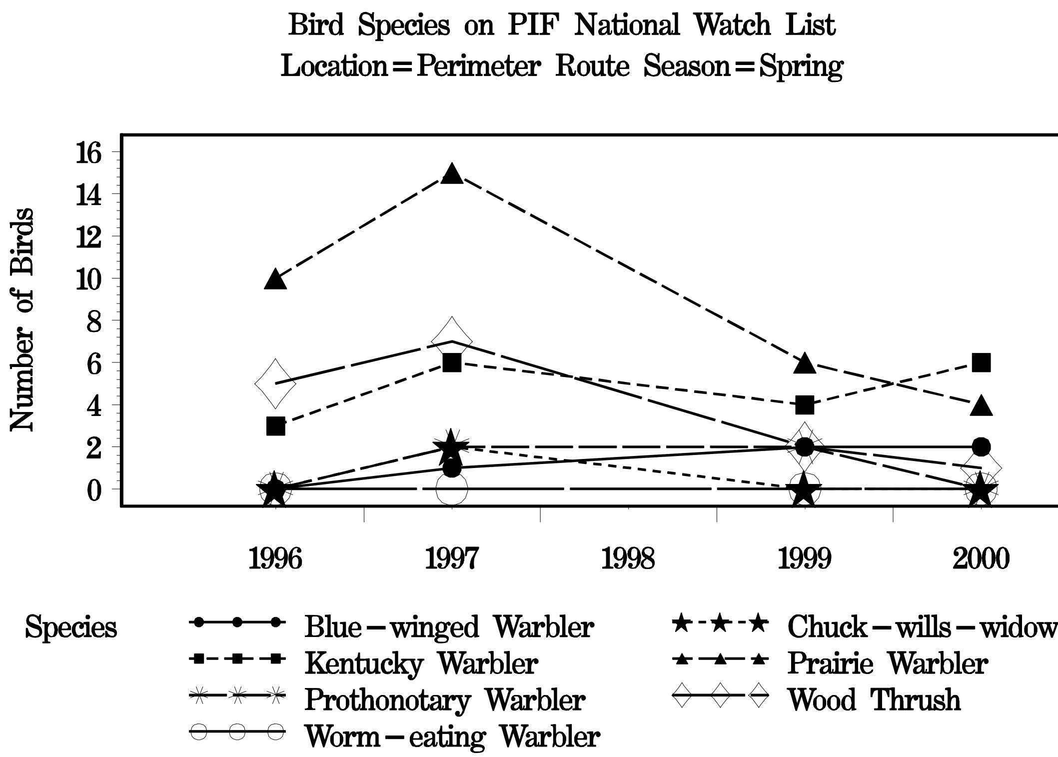

Figure 11. Number of birds counted on PIF Watch List at ED-1 in Spring by species on perimeter route.

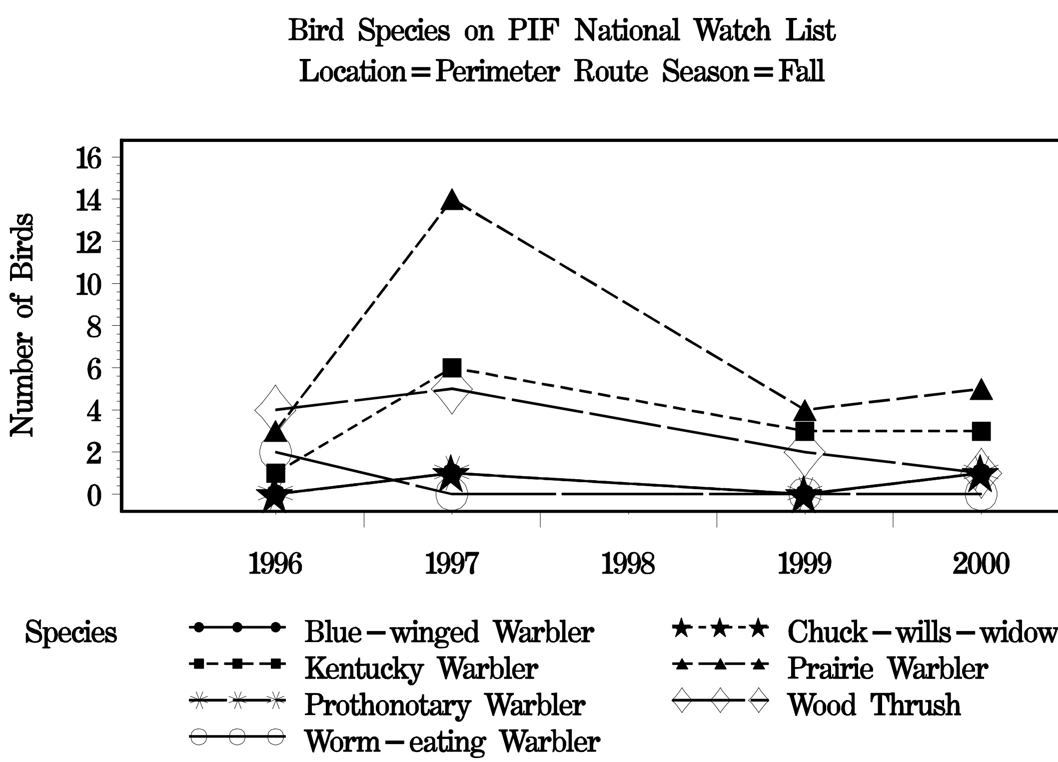

Figure 12. Number of birds counted on PIF Watch List at ED-1 in Fall by species on perimeter route.

Table 1. Total Numbers of Birds and Species by Locations, Seasons, and Year 1996-2000

Location	Year	Season	Total Birds	Total Species
Floodplain Route	1996	Spring	152	40
Floodplain Route	1997	Spring	236	43
Floodplain Route	1999	Spring	131	33
Floodplain Route	2000	Spring	144	37
Floodplain Route	1996	Fall	135	36
Floodplain Route	1997	Fall	193	40
Floodplain Route	1999	Fall	96	29
Floodplain Route	2000	Fall	158	34
Perimeter Route	1996	Spring	129	35
Perimeter Route	1997	Spring	231	43
Perimeter Route	1999	Spring	100	31
Perimeter Route	2000	Spring	134	35
Perimeter Route	1996	Fall	145	37
Perimeter Route	1997	Fall	192	41
Perimeter Route	1999	Fall	93	29
Perimeter Route	2000	Fall	125	36

Table 2. Summary Statistics for Total Birds 1996-2000

Season	Location	Total Number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for normality
Spring	Floodplain Route	4	165.75	47.6261	28.7337	236	131	0.79375
Spring	Perimeter Route	4	148.50	57.0058	38.3878	231	100	0.84687
Fall	Floodplain Route	4	145.50	40.7145	27.9824	193	96	0.99917
Fall	Perimeter Route	4	138.75	41.4598	29.8810	192	93	0.98766

Table 3. Summary Statistics for Total Species 1996-2000

Season	Location	Total number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for normality
Spring	Floodplain Route	4	38.25	4.27200	11.1686	43	33	0.99253
Spring	Perimeter Route	4	36.00	5.03322	13.9812	43	31	0.89495
Fall	Floodplain Route	4	34.75	4.57347	13.1611	40	29	0.99271
Fall	Perimeter Route	4	35.75	4.99166	13.9627	41	29	0.94698

Table 4. Summary Regression Table for Total Birds 1996-2000

Location	Season	Parameter Estimate	Standard Error	Pr > |t|	R-Square	LCL	UCL
Floodplain Route	Spring	-12.10000	16.34113	0.5361	0.2152	-82.4102	58.2102
Floodplain Route	Fall	-5.10000	15.35073	0.7713	0.0523	-71.1489	60.9489
Perimeter Route	Spring	-12.10000	20.35301	0.6125	0.1502	-99.6719	75.4719
Perimeter Route	Fall	-13.90000	12.69774	0.3879	0.3747	-68.5339	40.7339

Table 5. Summary Regression Table for Total Species 1996-2000

Location	Season	Parameter Estimate	Standard Error	Pr > |t|	R-Square	LCL	UCL
Floodplain Route	Spring	-1.60000	1.20727	0.3162	0.4676	-6.7945	3.5945
Floodplain Route	Fall	-1.50000	1.41863	0.4012	0.3586	-7.6039	4.6039
Perimeter Route	Spring	-1.20000	1.75499	0.5647	0.1895	-8.7511	6.3511
Perimeter Route	Fall	-1.40000	1.66057	0.4879	0.2622	-8.5449	5.7449

Table 6. Total Number of Birds of Conservation Concern and Total Number Birds on the PIF National Watch List, 1996-2000.

Location	Year	Season	Birds of Conservation Concern	PIF National Watch List
Floodplain Route	1996	Spring	60	10
Floodplain Route	1997	Spring	104	23
Floodplain Route	1999	Spring	31	9
Floodplain Route	2000	Spring	39	7
Floodplain Route	1996	Fall	51	7
Floodplain Route	1997	Fall	83	21
Floodplain Route	1999	Fall	32	2
Floodplain Route	2000	Fall	38	4
Perimeter Route	1996	Spring	56	18
Perimeter Route	1997	Spring	112	33
Perimeter Route	1999	Spring	39	16
Perimeter Route	2000	Spring	55	13
Perimeter Route	1996	Fall	54	10
Perimeter Route	1997	Fall	94	28
Perimeter Route	1999	Fall	43	9
Perimeter Route	2000	Fall	45	12

Table 7. Summary Statistics for Total Birds of Conservation Concern.

Season	Location	Total number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for normality
Spring	Floodplain Route	4	58.5	32.7058	55.9073	104	31	0.89740
Spring	Perimeter Route	4	65.5	31.9635	48.7993	112	39	0.82668
Fall	Floodplain Route	4	51.0	22.7596	44.6267	83	32	0.89112
Fall	Perimeter Route	4	59.0	23.8188	40.3708	94	43	0.78479

Table 8. Summary Statistics for Birds on the PIF National Watch List.

Season	Location	Total number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for normality
Spring	Floodplain Route	4	12.25	7.27438	59.383	23	7	0.78490
Spring	Perimeter Route	4	20.00	8.90693	44.535	33	13	0.83273
Fall	Floodplain Route	4	8.50	8.58293	100.976	21	2	0.83164
Fall	Perimeter Route	4	14.75	8.92095	60.481	28	9	0.75104

Table 9. Summary Regression Table for Birds of Conservation Concern.

Location	Season	Parameter Estimate	Standard Error	Pr > |t|	R-Square	LCL	UCL
Floodplain Route	Spring	-11.50000	9.71211	0.3580	0.4121	-53.2878	30.2878
Floodplain Route	Fall	-7.70000	6.93217	0.3823	0.3815	-37.5267	22.1267
Perimeter Route	Spring	-7.50000	11.18593	0.5716	0.1835	-55.6292	40.6292
Perimeter Route	Fall	-6.90000	7.82911	0.4711	0.2797	-40.5860	26.7860

Table 10. Summary Regression Table for Birds on the PIF National Watch List.

Location	Season	Parameter Estimate	Standard Error	Pr > |t|	R-Square	LCL	UCL
Floodplain Route	Spring	-2.00000	2.43670	0.4980	0.2520	-12.4843	8.4843
Floodplain Route	Fall	-2.50000	2.81514	0.4682	0.2828	-14.6126	9.6126
Perimeter Route	Spring	-2.70000	2.87315	0.4466	0.3063	-15.0622	9.6622
Perimeter Route	Fall	-1.50000	3.28824	0.6930	0.0942	-15.6481	12.6481

Benthic Macroinvertebrate Monitoring Data

Data Sources

Data were obtained from three sources: OREIS, Lockwood Green Technologies, and hand entry from the ED-1 MAP reports. OREIS data were received as a tab-delimited ASCII file queried from the OREIS database. The OREIS data included the population surveys of benthic macroinvertebrates at EFK 6.3 from 1985 through 1999 and at BCK3.3 from 1984 through 2001. Lockwood Green data were received as Excel spreadsheets. These data included benthic macroinvertebrate surveys from 1998 to 2000. Data were hand entered into Excel spreadsheets from the 1997 MAP reports.

Data Processing

SAS data analysis software was used to summarize and graph the data. The total number of benthic organisms was summed across each location, year, season and sampler. From 3 to 5 surber samplers were used at each location and sampling event. From the sum per sampler, the average number of organisms and taxa per sample were computed (Table 1). The taxa included in the Ephemeroptera, Tricoptera, and Plecoptera (EPT) orders of insects were identified. The total number of organisms in these three orders was summed for each sample and the average was used to calculate the percent EPT organisms for each location and sampling event (Table 1). The percent of chironomid organisms was calculated in a similar manner (Table 1). These data for each location, season, were plotted by year to allow for a visual examination of temporal trends in the data (Figures 1 to 12).

Summary statistics were calculated for the average number of organisms per sample and the average number of taxa per sample for each season and location (Tables 2 and 3). The summary statistics include the total number of samples, mean, standard deviation, coefficient of variation, maximum, minimum, and the probability for normality test. The coefficient of variation (CV) is the standard deviation divided by the mean and taken as a percent. The CV is a measure of the variability of the measurement. The probability for normality test is the probability for the Shapiro-Wilk test for determining if the data are different from a normal distribution. Data with probability values less than 0.05 would be considered significantly different from normal.

A simple linear regression analysis was performed for the average number of benthic organisms versus year and the average number of taxa versus year to look for a simple linear increase or decrease in the ecological measurements over time. The regression tables contain the parameter estimates for the slope, standard error, probability, R-square, and 95% lower (LCL) and upper (UCL) confidence limits on the slope. Probability values less than the alpha level chosen indicate a statistically significant slope and, therefore, a statistically significant trend. The R-square value indicates how well the linear regression fits the measurements. R-square values close to 1.0 indicate a very good fit. R-square values close to zero indicate a poor fit (Tables 4 and 5).

Plots (Figures 9 to 12), summary statistics (Tables 6 and 7), and regression analyses (Tables 8 and 9) were also computed for the percent EPT and percent chironomid data.

References

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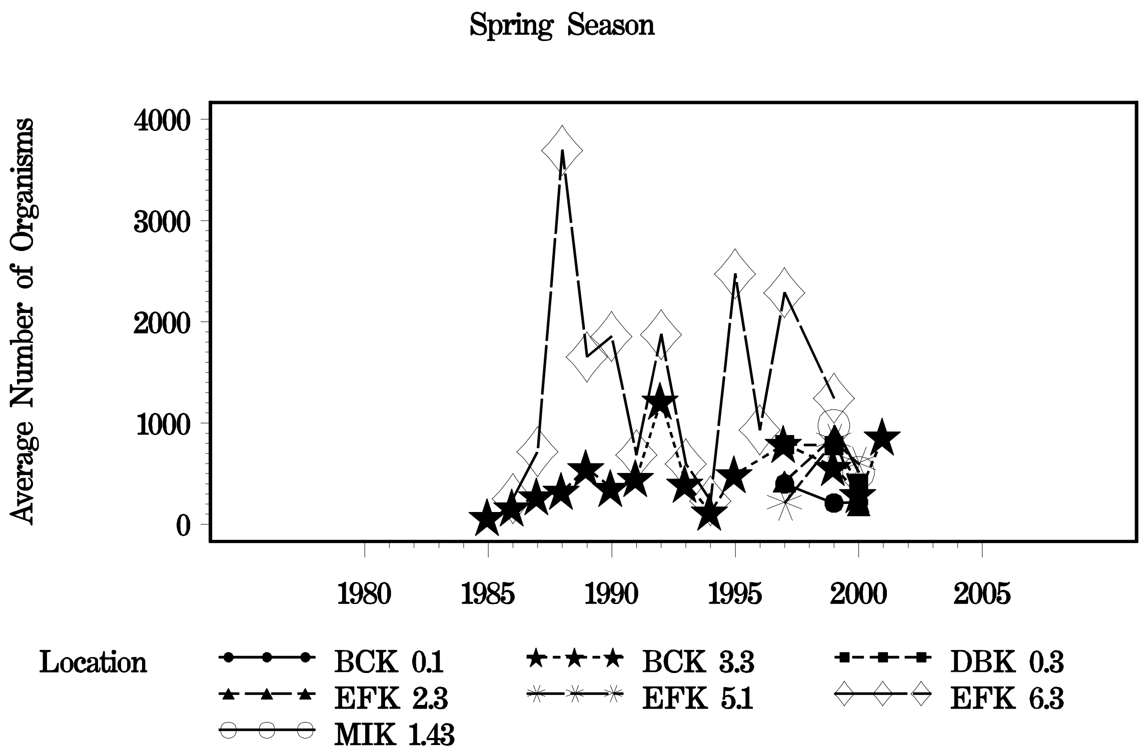

Figure 1. Average number of benthic organisms per sample for the Spring sampling events 1985-2001.

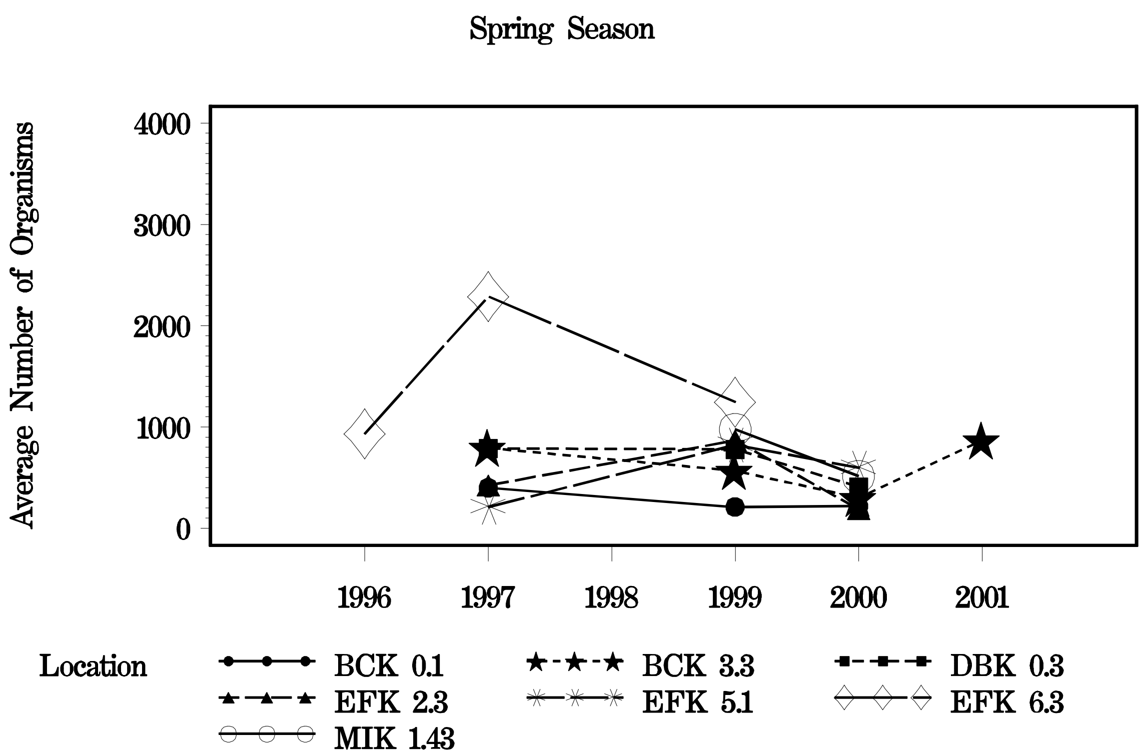

Figure 2. Average number of benthic organisms per sample for the Spring sampling events 1996-2001.

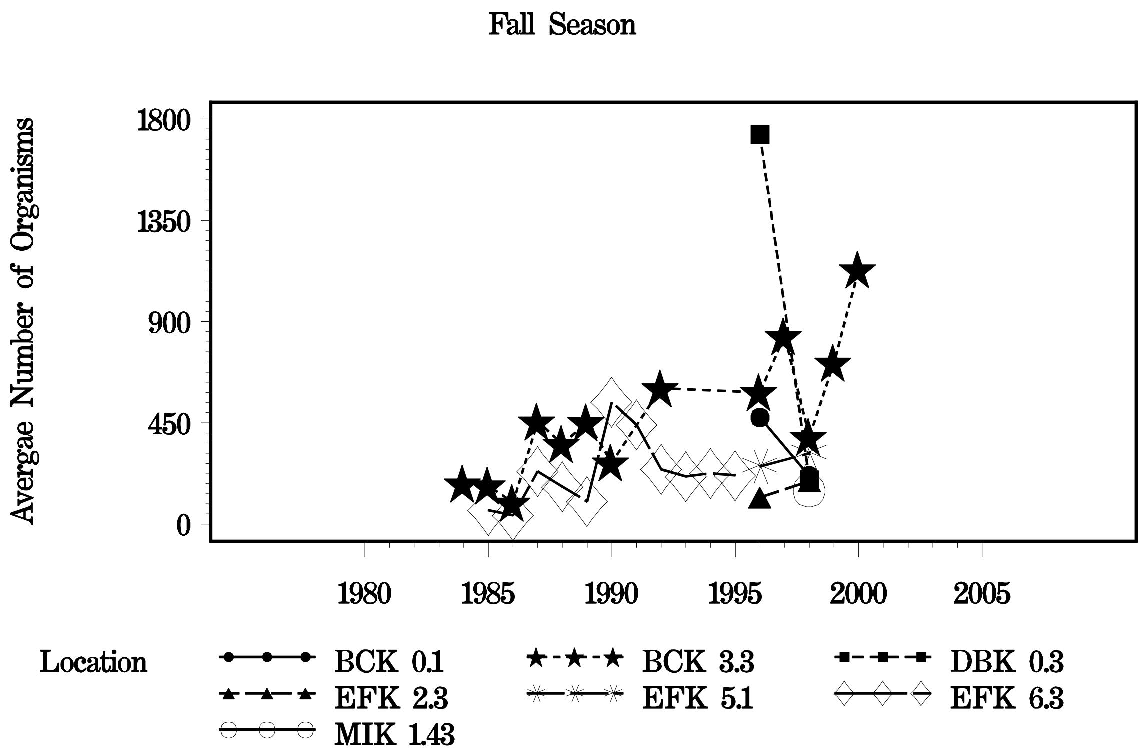

Figure 3. Average number of benthic organisms per sample for the Fall sampling events 1984-2000.

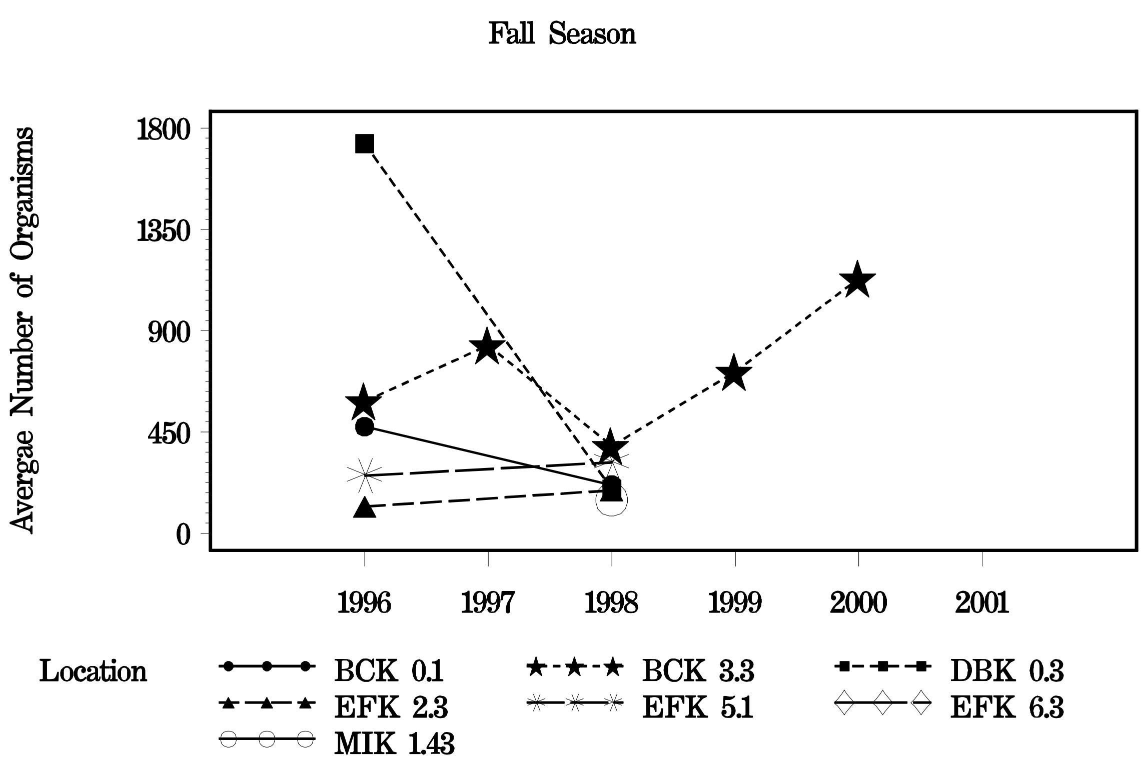

Figure 3. Average number of benthic organisms per sample for the Fall sampling events 1996-2000.

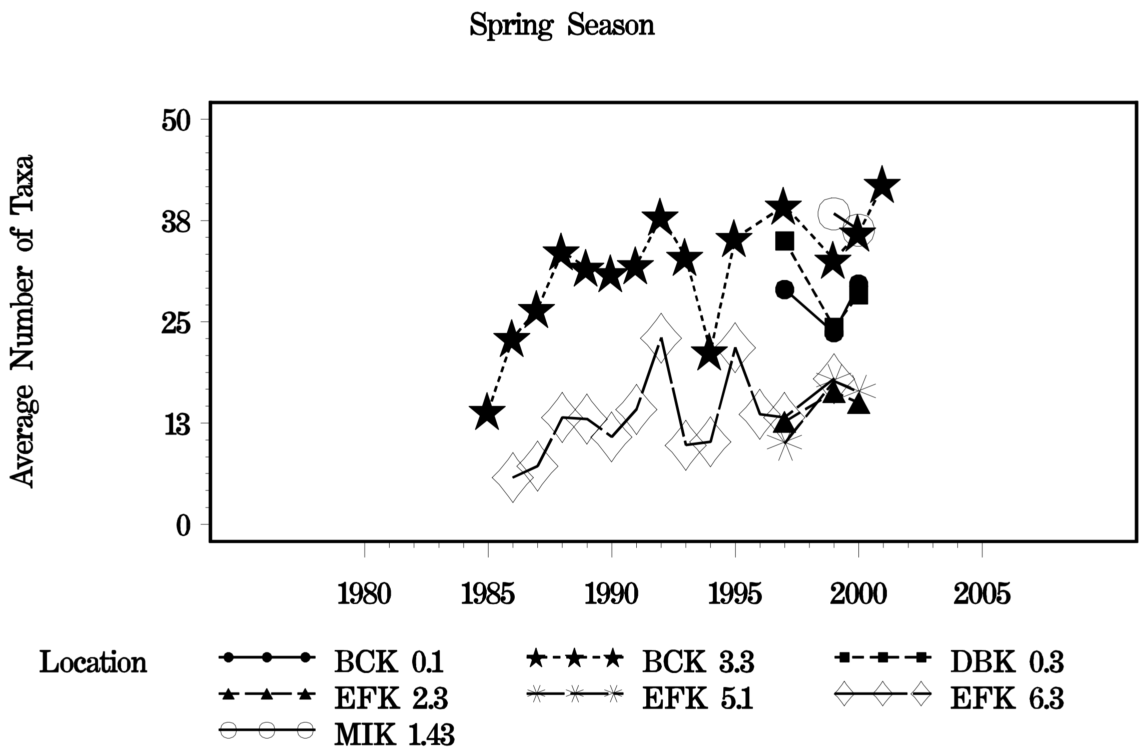

Figure 5. Average number of benthic taxa per sample for the Spring sampling events 1985-2001.

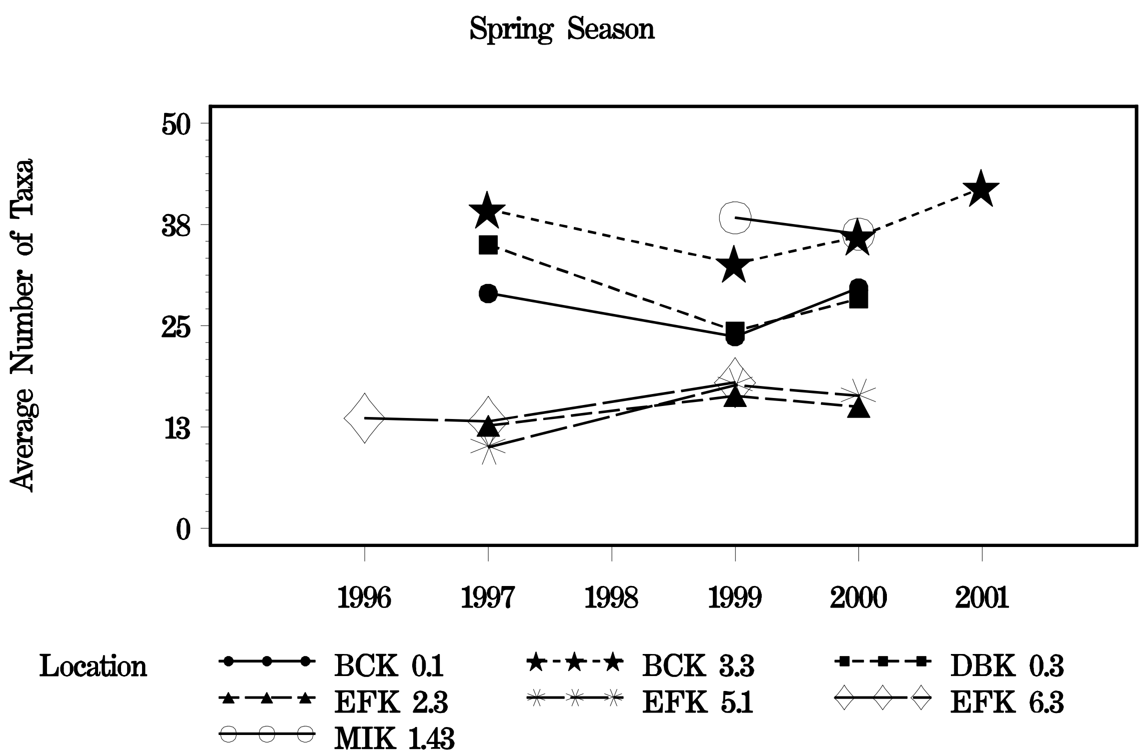

Figure 6. Average number of benthic taxa per sample for the Spring sampling events 1996-2001.

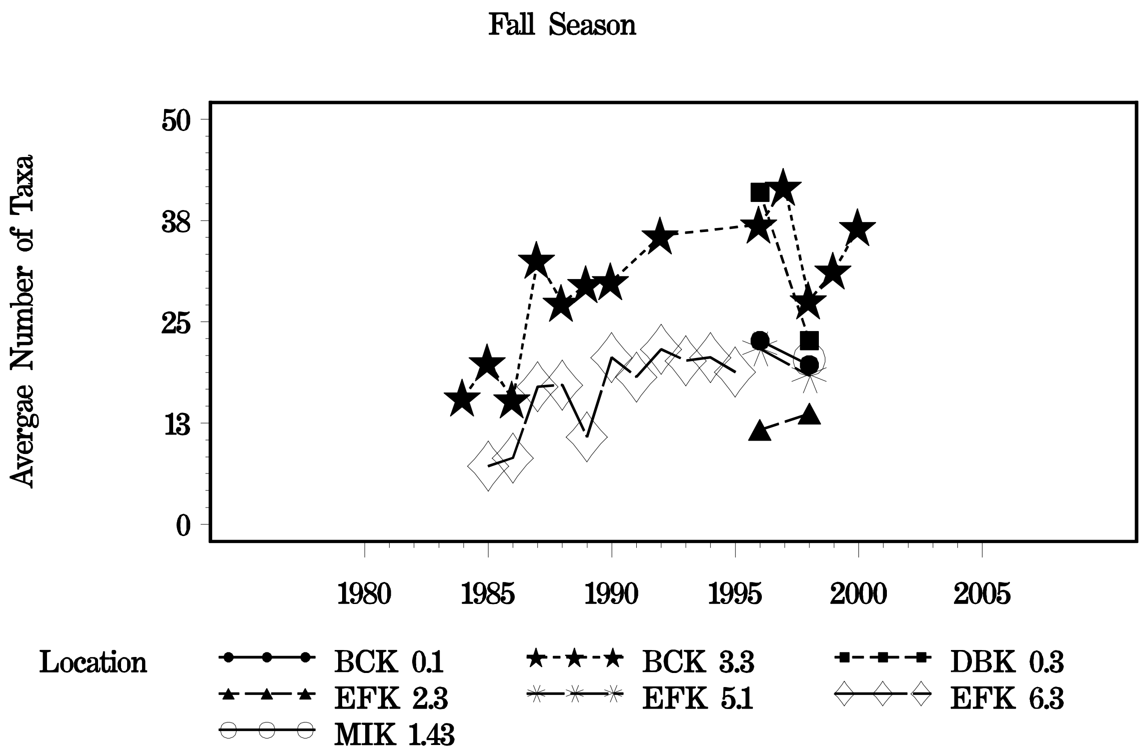

Figure 7. Average number of benthic taxa per sample for the Fall sampling events 1984- 2000.

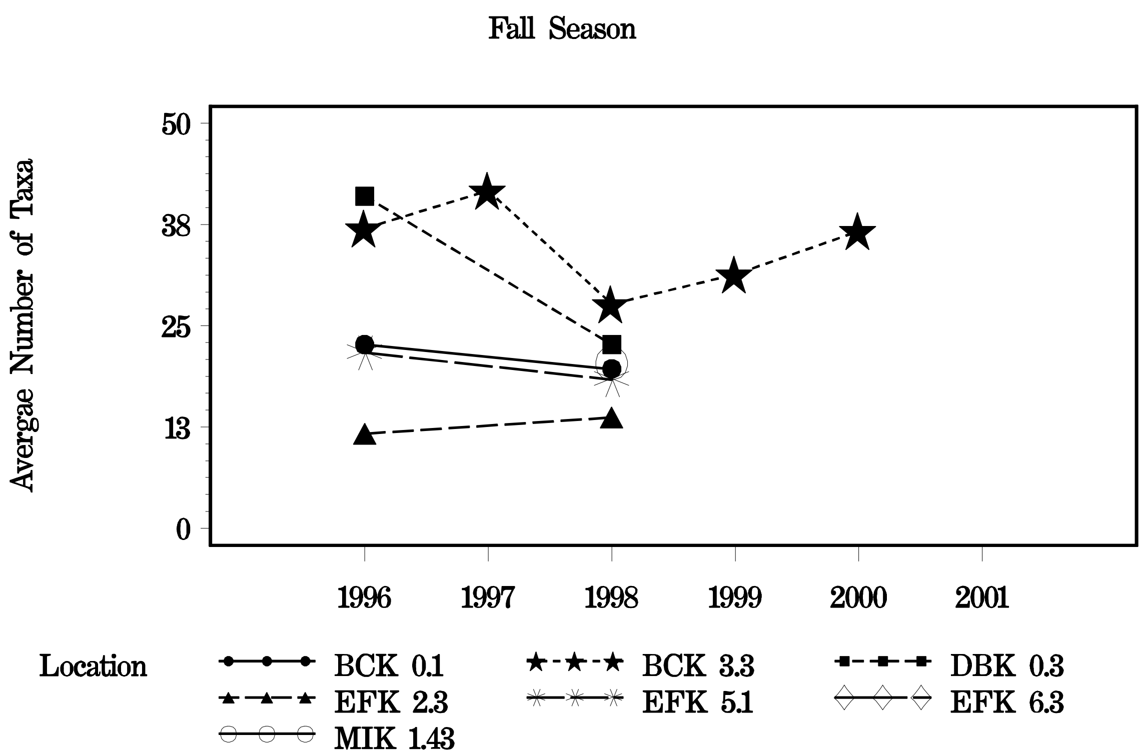

Figure 8. Average number of benthic taxa per sample for the Fall sampling events 1996- 2000.

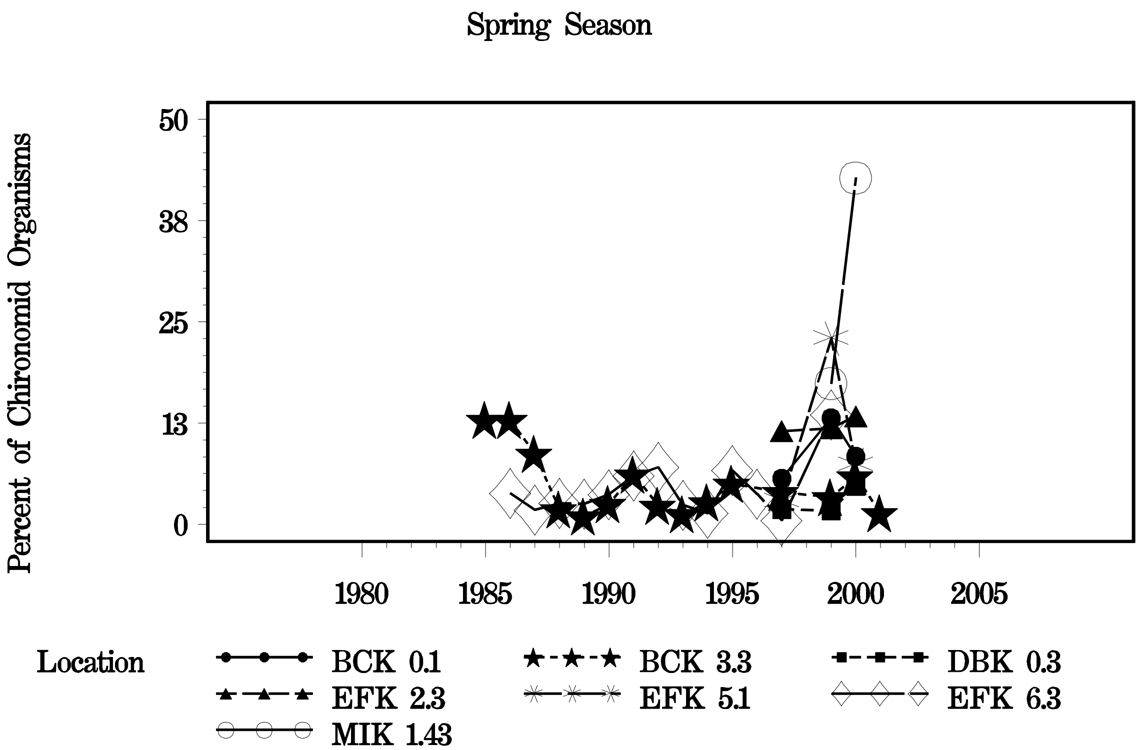

Figure 9. Percent chironomid organisms per sample for the Spring sampling events 1985- 2001.

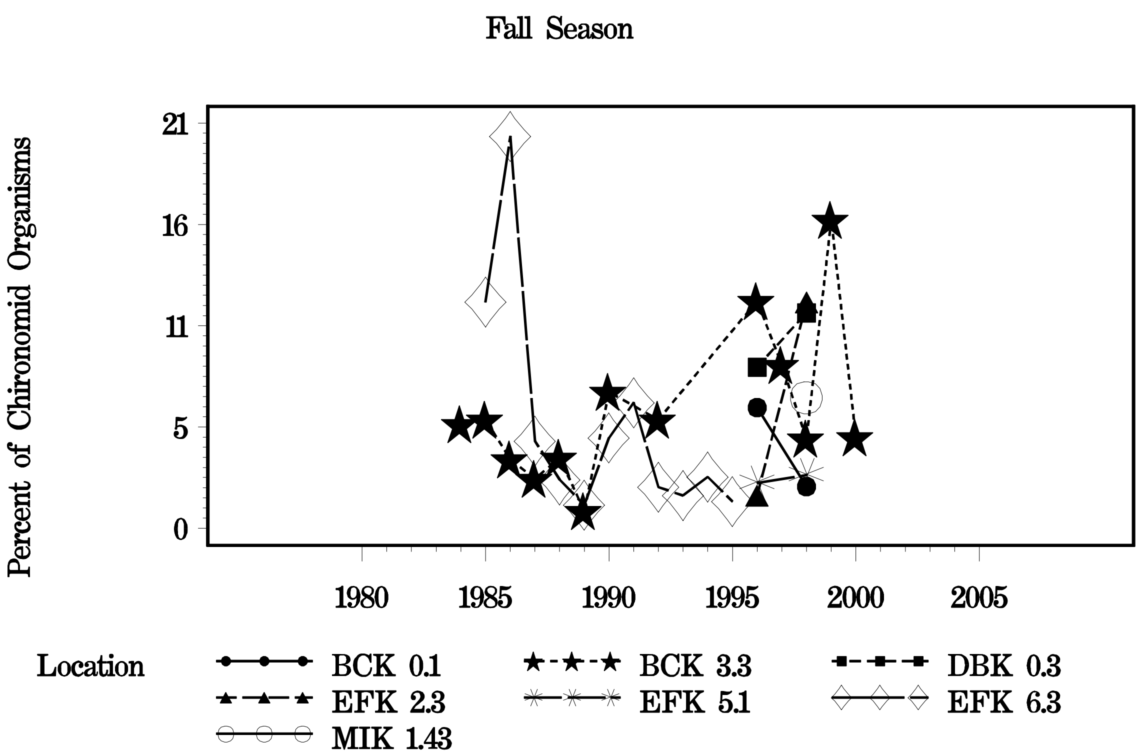

Figure 10. Percent chironomid organisms per sample for the Fall sampling events 1984- 2000.

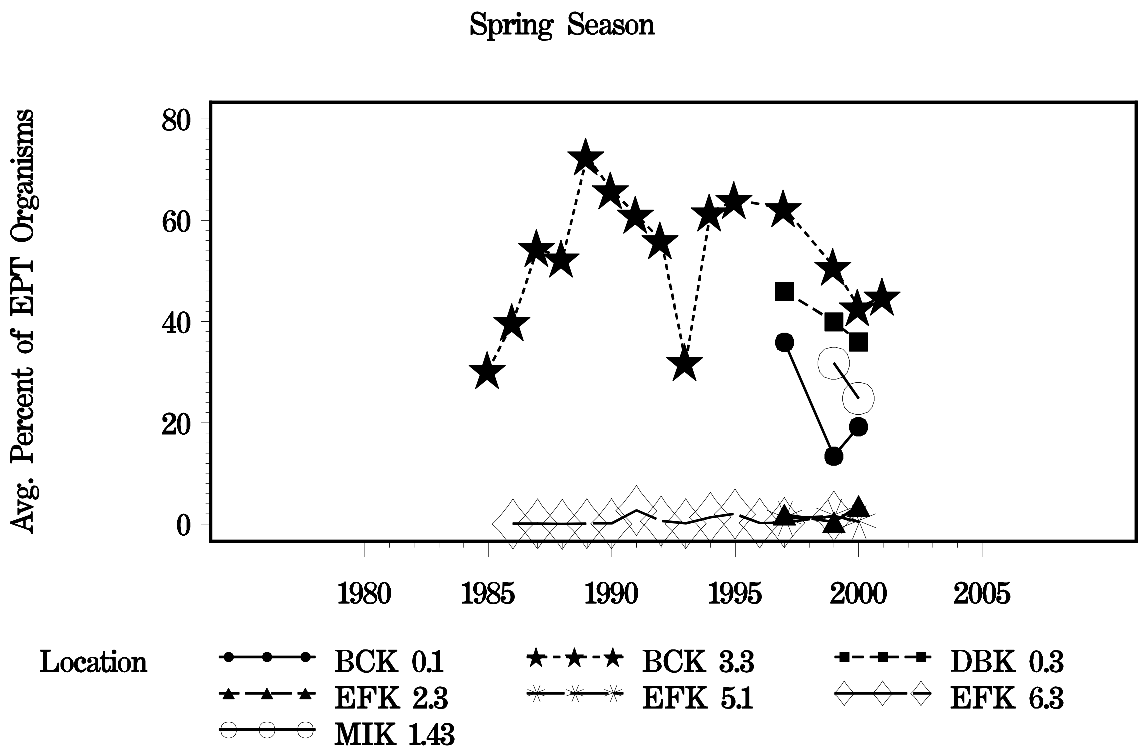

Figure 11. Percent EPT organisms per sample for the Spring sampling events 1985- 2001.

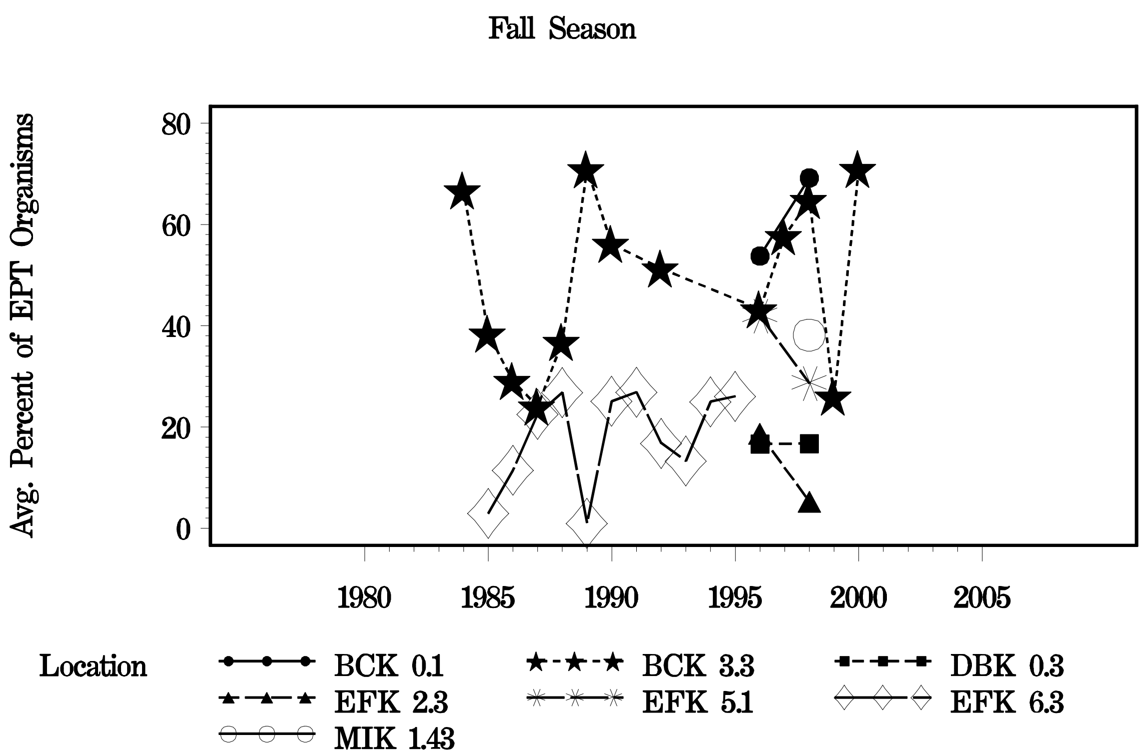

Figure 12. Percent EPT organisms per sample for the Fall sampling events 1984- 2000.

Table 1. ED-1 Benthic Data Summarized by Event

Location	Year	Season	Average Number of Organisms per Sample	Average Number of Taxa per Sample	Average Percent of EPT Organisms	Average Percent of Chironomid Organisms
BCK 0.1	1997	Spring	400	29	36	6
BCK 0.1	1999	Spring	210	24	13	13
BCK 0.1	2000	Spring	222	30	19	8
BCK 0.1	1996	Fall	474	23	54	6
BCK 0.1	1998	Fall	215	20	69	2
BCK 3.3	1985	Spring	72	14	30	13
BCK 3.3	1986	Spring	167	23	40	13
BCK 3.3	1987	Spring	278	27	54	9
BCK 3.3	1988	Spring	329	34	52	2
BCK 3.3	1989	Spring	553	32	73	1
BCK 3.3	1990	Spring	358	31	66	3
BCK 3.3	1991	Spring	456	32	61	6
BCK 3.3	1992	Spring	1221	38	56	2
BCK 3.3	1993	Spring	401	33	32	1
BCK 3.3	1994	Spring	124	21	62	3
BCK 3.3	1995	Spring	493	35	64	5
BCK 3.3	1997	Spring	793	39	62	4
BCK 3.3	1999	Spring	567	33	51	3
BCK 3.3	2000	Spring	300	36	43	6
BCK 3.3	2001	Spring	868	42	45	1
BCK 3.3	1984	Fall	179	16	67	5
BCK 3.3	1985	Fall	171	20	38	6
BCK 3.3	1986	Fall	95	15	29	4
BCK 3.3	1987	Fall	456	33	24	3
BCK 3.3	1988	Fall	355	27	37	4
BCK 3.3	1989	Fall	453	30	71	1
BCK 3.3	1990	Fall	274	30	56	7
BCK 3.3	1992	Fall	604	36	51	6
BCK 3.3	1996	Fall	586	37	43	12
BCK 3.3	1997	Fall	835	42	58	8
BCK 3.3	1998	Fall	388	28	65	5
BCK 3.3	1999	Fall	717	31	26	16
BCK 3.3	2000	Fall	1132	37	71	5
DBK 0.3	1997	Spring	788	35	46	2
DBK 0.3	1999	Spring	781	24	40	2
DBK 0.3	2000	Spring	407	28	36	5
DBK 0.3	1996	Fall	1731	41	17	8
DBK 0.3	1998	Fall	197	23	17	11
EFK 2.3	1997	Spring	423	13	2	11
EFK 2.3	1999	Spring	867	16	0	12
EFK 2.3	2000	Spring	187	15	4	13
EFK 2.3	1996	Fall	118	12	19	2
EFK 2.3	1998	Fall	191	14	5	12
EFK 5.1	1997	Spring	208	10	1	3
EFK 5.1	1999	Spring	824	18	2	23
EFK 5.1	2000	Spring	597	16	0	7
EFK 5.1	1996	Fall	256	22	42	2
EFK 5.1	1998	Fall	315	18	29	3

Table 1. ED-1 Benthic Data Summarized by Event (continued)

Location	Year	Season	Average Number of Organisms per Sample	Average Number of Taxa per Sample	Average Percent of EPT Organisms	Average Percent of Chironomid Organisms
EFK 6.3	1986	Spring	256	6	0	4
EFK 6.3	1987	Spring	720	7	0	2
EFK 6.3	1988	Spring	3694	13	0	3
EFK 6.3	1989	Spring	1655	13	0	3
EFK 6.3	1990	Spring	1857	11	0	4
EFK 6.3	1991	Spring	686	14	3	6
EFK 6.3	1992	Spring	1875	23	1	7
EFK 6.3	1993	Spring	599	10	0	2
EFK 6.3	1994	Spring	234	10	1	1
EFK 6.3	1995	Spring	2474	22	2	7
EFK 6.3	1996	Spring	933	14	0	4
EFK 6.3	1997	Spring	2289	13	0	0
EFK 6.3	1999	Spring	1247	18	2	14
EFK 6.3	1985	Fall	61	7	3	12
EFK 6.3	1986	Fall	38	8	11	20
EFK 6.3	1987	Fall	234	17	23	5
EFK 6.3	1988	Fall	166	17	27	3
EFK 6.3	1989	Fall	100	11	1	1
EFK 6.3	1990	Fall	542	21	25	5
EFK 6.3	1991	Fall	442	18	27	7
EFK 6.3	1992	Fall	244	22	17	2
EFK 6.3	1993	Fall	212	20	13	2
EFK 6.3	1994	Fall	226	21	25	3
EFK 6.3	1995	Fall	216	19	26	1
MIK 1.43	1999	Spring	976	38	32	17
MIK 1.43	2000	Spring	514	36	25	43
MIK 1.43	1998	Fall	148	20	38	7

Table 2. Benthic Data Summary Statistics for the Average Number of Organisms per Sample

Season	Location	Total number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for normality
Spring	BCK 0.1	3	277.44	106.30	38.313	400.00	210.333	0.79595
Spring	BCK 3.3	15	465.48	306.66	65.880	1221.33	72.333	0.92088
Spring	DBK 0.3	3	658.67	217.69	33.050	788.00	407.333	0.76444
Spring	EFK 2.3	3	492.67	345.26	70.080	867.33	187.333	0.96976
Spring	EFK 5.1	3	542.89	311.17	57.318	823.67	208.333	0.97760
Spring	EFK 6.3	13	1424.55	1009.23	70.845	3694.20	234.000	0.92712
Spring	MIK 1.43	2	745.00	327.15	43.913	976.33	513.667	1.00000
Fall	BCK 0.1	2	344.67	182.90	53.067	474.00	215.333	1.00000
Fall	BCK 3.3	13	480.34	293.87	61.180	1132.00	95.000	0.94900
Fall	DBK 0.3	2	964.00	1084.70	112.521	1731.00	197.000	1.00000
Fall	EFK 2.3	2	154.33	51.38	33.294	190.67	118.000	1.00000
Fall	EFK 5.1	2	285.33	41.48	14.539	314.67	256.000	1.00000
Fall	EFK 6.3	11	225.64	151.25	67.034	541.80	38.400	0.89008
Fall	MIK 1.43	1	147.67	.	.	147.67	147.667	.

Table 3. Benthic Data Summary Statistics for the Average Number of Taxa per Sample

Season	Location	Total number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for normality
Spring	BCK 0.1	3	27.4444	3.2886	11.9827	29.6667	23.6667	0.83219
Spring	BCK 3.3	15	31.3067	7.3822	23.5802	42.0000	14.0000	0.93319
Spring	DBK 0.3	3	29.2222	5.3886	18.4401	35.0000	24.3333	0.97959
Spring	EFK 2.3	3	14.6667	1.8559	12.6540	16.3333	12.6667	0.97581
Spring	EFK 5.1	3	14.6667	4.0961	27.9277	17.6667	10.0000	0.87583
Spring	EFK 6.3	13	13.3692	5.0904	38.0756	23.0000	5.8000	0.93492
Spring	MIK 1.43	2	37.3333	1.4142	3.7881	38.3333	36.3333	1.00000
Fall	BCK 0.1	2	21.1667	2.1213	10.0220	22.6667	19.6667	1.00000
Fall	BCK 3.3	13	29.2872	8.1405	27.7956	41.6667	15.4000	0.93373
Fall	DBK 0.3	2	31.8333	12.9636	40.7234	41.0000	22.6667	1.00000
Fall	EFK 2.3	2	12.6667	1.4142	11.1648	13.6667	11.6667	1.00000
Fall	EFK 5.1	2	20.0000	2.3570	11.7851	21.6667	18.3333	1.00000
Fall	EFK 6.3	11	16.4000	5.1962	31.6839	21.6000	7.2000	0.82890
Fall	MIK 1.43	1	20.3333	.	.	20.3333	20.3333	.

Table 4. Benthic Data Summary Regression Table for the Average Number of Organisms per Sample

Location	Season	Parameter Estimate	Standard Error	Pr > |t|	R-Square	LCL	UCL
BCK 0.1	Spring	-64.40476	26.35192	0.2472	0.8566	-399.24	270.43
BCK 0.1	Fall	-129.33333	.	.	1.0000	.	.
BCK 3.3	Spring	26.95972	14.76491	0.0909	0.2041	-4.9379	58.8574
BCK 3.3	Fall	42.23581	8.87341	0.0006	0.6732	22.7056	61.7661
DBK 0.3	Spring	-109.28571	91.46878	0.4436	0.5881	-1271.51	1052.94
DBK 0.3	Fall	-767.00000	.	.	1.0000	.	.
EFK 2.3	Spring	-35.71429	223.18712	0.8990	0.0250	-2871.58	2800.15
EFK 2.3	Fall	36.33333	.	.	1.0000	.	.
EFK 5.1	Spring	154.90476	132.29569	0.4500	0.5782	-1526.07	1835.88
EFK 5.1	Fall	29.33333	.	.	1.0000	.	.
EFK 6.3	Spring	8.65391	75.45602	0.9108	0.0012	-157.42	174.73
EFK 6.3	Fall	17.76364	14.00078	0.2364	0.1517	-13.9083	49.4356
MIK 1.43	Spring	-462.66667	.	.	1.0000	.	.
MIK 1.43	Fall	0	.	.	.	.	.

Table 5. Benthic Data Summary Regression Table for the Average Number of Taxa per Sample

Location	Season	Parameter Estimate	Standard Error	Pr > |t|	R-Square	LCL	UCL
BCK 0.1	Spring	-0.19048	2.14444	0.9436	0.0078	-27.4382	27.0573
BCK 0.1	Fall	-1.50000	.	.	1.0000	.	.
BCK 3.3	Spring	0.97688	0.29210	0.0053	0.4625	0.3458	1.6079
BCK 3.3	Fall	1.02802	0.29796	0.0054	0.5197	0.3722	1.6838
DBK 0.3	Spring	-2.66667	2.30940	0.4544	0.5714	-32.0104	26.6771
DBK 0.3	Fall	-9.16667	.	.	1.0000	.	.
EFK 2.3	Spring	0.92857	0.78355	0.4462	0.5841	-9.0273	10.8845
EFK 2.3	Fall	1.00000	.	.	1.0000	.	.
EFK 5.1	Spring	2.35714	1.27842	0.3164	0.7727	-13.8867	18.6010
EFK 5.1	Fall	-1.66667	.	.	1.0000	.	.
EFK 6.3	Spring	0.66811	0.32317	0.0631	0.2798	-0.04319	1.3794
EFK 6.3	Fall	1.21273	0.33063	0.0052	0.5992	0.4648	1.9607
MIK 1.43	Spring	-2.00000	.	.	1.0000	.	.
MIK 1.43	Fall	0	.	.	.	.	.

Table 6. Benthic Data Summary Statistics for the Average Percent of Chironomid Organisms

Season	Location	Total number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for normality
Spring	BCK 0.1	3	9.0763	3.7879	41.735	13.1537	5.6667	0.97669
Spring	BCK 3.3	15	4.7837	3.9307	82.169	12.9032	0.9639	0.83039
Spring	DBK 0.3	3	2.7718	1.7117	61.752	4.7463	1.7079	0.78774
Spring	EFK 2.3	3	12.2389	0.9767	7.980	13.3452	11.4961	0.89615
Spring	EFK 5.1	3	11.0347	10.5174	95.312	22.9057	2.8800	0.90636
Spring	EFK 6.3	13	4.2764	3.4305	80.219	13.5204	0.4806	0.83776
Spring	MIK 1.43	2	30.0712	17.9510	59.695	42.7644	17.3779	1.00000
Fall	BCK 0.1	2	4.2130	2.8932	68.673	6.2588	2.1672	1.00000
Fall	BCK 3.3	13	6.1514	4.0159	65.285	15.9851	0.8837	0.88337
Fall	DBK 0.3	2	9.7625	1.9870	20.354	11.1675	8.3574	1.00000
Fall	EFK 2.3	2	6.7041	7.0841	105.668	11.7133	1.6949	1.00000
Fall	EFK 5.1	2	2.5490	0.2903	11.387	2.7542	2.3438	1.00000
Fall	EFK 6.3	11	5.3973	5.8209	107.850	20.3125	1.2000	0.72987
Fall	MIK 1.43	1	6.7720	.	.	6.7720	6.7720	.

Table 7. Benthic Data Summary Statistics for the Average Percent of EPT Organisms

Season	Location	Total number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for normality
Spring	BCK 0.1	3	22.8689	11.6596	50.984	35.9167	13.4707	0.92652
Spring	BCK 3.3	15	52.7560	12.5501	23.789	72.5904	30.4147	0.95675
Spring	DBK 0.3	3	40.6513	5.0226	12.355	45.9814	36.0065	0.98603
Spring	EFK 2.3	3	1.9443	1.5879	81.671	3.5587	0.3843	0.99912
Spring	EFK 5.1	3	1.0484	0.5691	54.280	1.5783	0.4469	0.98813
Spring	EFK 6.3	13	0.7226	0.8989	124.411	2.7098	0.0054	0.77481
Spring	MIK 1.43	2	28.3198	4.9014	17.307	31.7856	24.8540	1.00000
Fall	BCK 0.1	2	61.4963	10.8877	17.705	69.1950	53.7975	1.00000
Fall	BCK 3.3	13	48.9288	17.0872	34.922	70.9364	24.0497	0.91957
Fall	DBK 0.3	2	16.7042	0.0666	0.399	16.7513	16.6570	1.00000
Fall	EFK 2.3	2	11.9444	9.4747	79.324	18.6441	5.2448	1.00000
Fall	EFK 5.1	2	35.2644	9.4225	26.720	41.9271	28.6017	1.00000
Fall	EFK 6.3	11	17.9908	9.6111	53.422	26.8778	1.0000	0.84680
Fall	MIK 1.43	1	38.1490	.	.	38.1490	38.1490	.

Table 8. Benthic Data Summary Regression Table for the Average Percent of Chironomid Organisms

Location	Season	Parameter Estimate	Standard Error	Pr > |t|	R-Square	LCL	UCL
BCK 0.1	Spring	-6.37398	4.19936	0.3709	0.6973	-59.7320	46.9840
BCK 0.1	Fall	7.69879	.	.	1.0000	.	.
BCK 3.3	Spring	0.12716	0.67640	0.8538	0.0027	-1.3341	1.5884
BCK 3.3	Fall	0.70347	0.87719	0.4396	0.0552	-1.2272	2.6342
DBK 0.3	Spring	-3.27964	0.23544	0.0456	0.9949	-6.2712	-0.2881
DBK 0.3	Fall	0.04712	.	.	1.0000	.	.
EFK 2.3	Spring	0.36931	0.97171	0.7688	0.1262	-11.9774	12.7161
EFK 2.3	Fall	-6.69966	.	.	1.0000	.	.
EFK 5.1	Spring	-0.15957	0.33665	0.7182	0.1835	-4.4371	4.1179
EFK 5.1	Fall	-6.66269	.	.	1.0000	.	.
EFK 6.3	Spring	0.09007	0.06152	0.1712	0.1631	-0.04534	0.2255
EFK 6.3	Fall	1.34546	0.85552	0.1502	0.2156	-0.5899	3.2808
MIK 1.43	Spring	-6.93160	.	.	1.0000	.	.
MIK 1.43	Fall	0	.	.	.	.	.

Table 9. Benthic Data Summary Statistics for the Average Percent of EPT Organisms

Location	Season	Parameter Estimate	Standard Error	Pr > |t|	R-Square	LCL	UCL
BCK 0.1	Spring	1.31814	2.10044	0.6432	0.2826	-25.3705	28.0068
BCK 0.1	Fall	-2.04580	.	.	1.0000	.	.
BCK 3.3	Spring	-0.38333	0.18358	0.0570	0.2512	-0.7799	0.01327
BCK 3.3	Fall	0.38223	0.17806	0.0550	0.2952	-0.00969	0.7741
DBK 0.3	Spring	0.81335	0.77077	0.4829	0.5269	-8.9802	10.6069
DBK 0.3	Fall	1.40505	.	.	1.0000	.	.
EFK 2.3	Spring	0.55542	0.31672	0.3299	0.7546	-3.4689	4.5797
EFK 2.3	Fall	5.00919	.	.	1.0000	.	.
EFK 5.1	Spring	2.69853	6.33439	0.7436	0.1536	-77.7875	83.1846
EFK 5.1	Fall	0.20524	.	.	1.0000	.	.
EFK 6.3	Spring	0.35784	0.23285	0.1526	0.1767	-0.1547	0.8704
EFK 6.3	Fall	-1.14784	0.44256	0.0290	0.4277	-2.1490	-0.1467
MIK 1.43	Spring	25.38649	.	.	1.0000	.	.
MIK 1.43	Fall	0	.	.	.	.	.

Fish Monitoring Data

Data Sources

Data were obtained from three sources: OREIS, Lockwood Green Technologies, and hand entry from the ED-1 MAP reports. OREIS data were received as a tab-delimited ASCII file queried from the OREIS database. The OREIS data included the population surveys of fish at EFK 6.3 from 1985 through 1997 and at BCK3.3 from 1988 through 2001. Lockwood Green data were received as Excel spreadsheets. These data included fish surveys from 1998 to 2000. Data were hand entered into Excel spreadsheets from the 1997 MAP reports.

Data Processing

SAS data analysis software was used to summarize and graph the data. The actual surface area of the stream sample was different for different sampling locations and sampling events. All of the fish population data were, therefore, reported as fish density (fish/m^2). The fish density and number of species captured were calculated for each location and sampling event (Table 1). The species were classified as piscivores or generalist feeders and as tolerant or intolerant species. The percentage of the total fish density comprising each of the three classifications (piscivore, generalist, tolerant) was calculated (Table 1). Note that tolerant species could include piscivores and generalist feeders. The data for each location and season were plotted by year to allow for a visual examination of temporal trends in the data (Figures 1 to 10).

Summary statistics were calculated for the fish density and number of species for each season and location (Tables 2 and 4). The summary statistics include the total number of samples, mean, standard deviation, coefficient of variation, maximum, minimum, and the probability for normality test. The coefficient of variation (CV) is the standard deviation divided by the mean and taken as a percent. The CV is a measure of the variability of the measurement. The probability for normality test is the probability for the Shapio-Wilk test for determining if the data are different from a normal distribution. Data with probability values less than 0.05 would be considered significantly different from normal.

A simple linear regression analysis was performed for the fish density and number of species versus year to look for a simple linear increase or decrease in the ecological measurements over time. The regression tables contain the parameter estimates for the slope, standard error, probability, R-square, and 95% lower (LCL) and upper (UCL) confidence limits on the slope. Probability values less than the alpha level chosen indicate a statistically significant slope and, therefore, a statistically significant trend. The R-square value indicates how well the linear regression fits the measurements. R-square values close to 1.0 indicate a very good fit. R-square values close to zero indicate a poor fit (Tables 3 and 5).

Plots (Figures 5 to 10), summary statistics (Tables 6, 8 and 9), and regression analyses (Tables 7, 9 and 11) were also computed for the percent generalist feeders, percent piscivores, and percent tolerant fish

References

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Proprietary Software Release 8.2 (TS2M0)

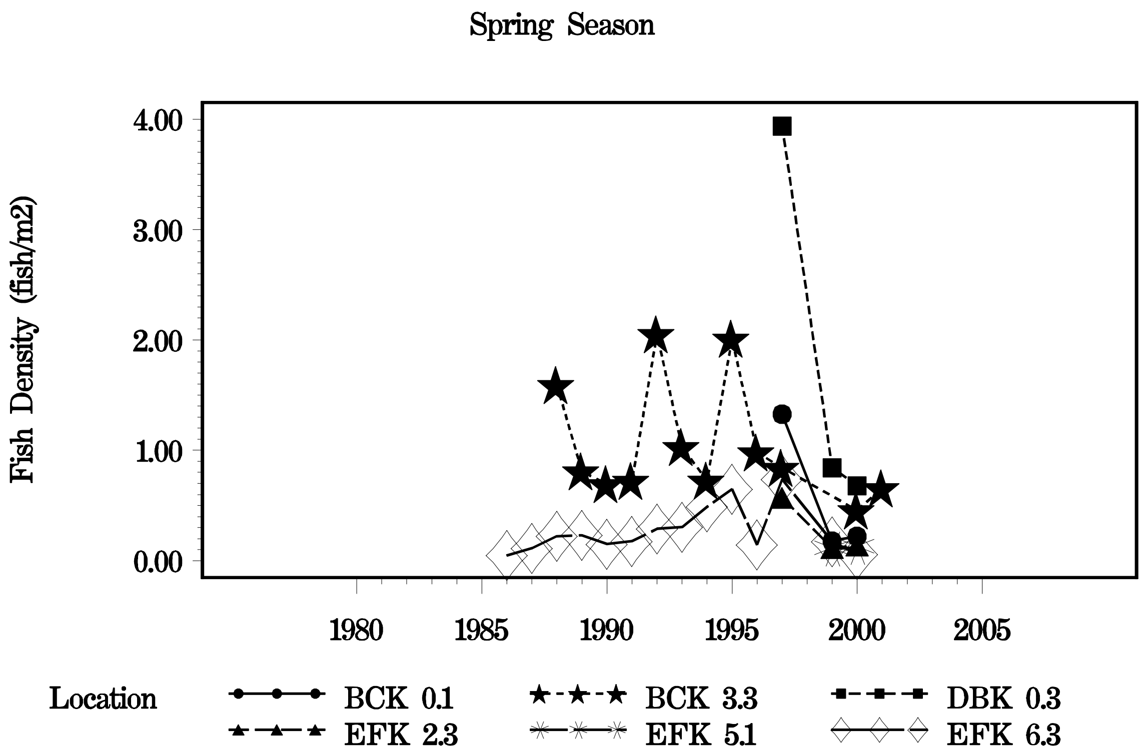

Figure 1. Fish density for the Spring sampling events.

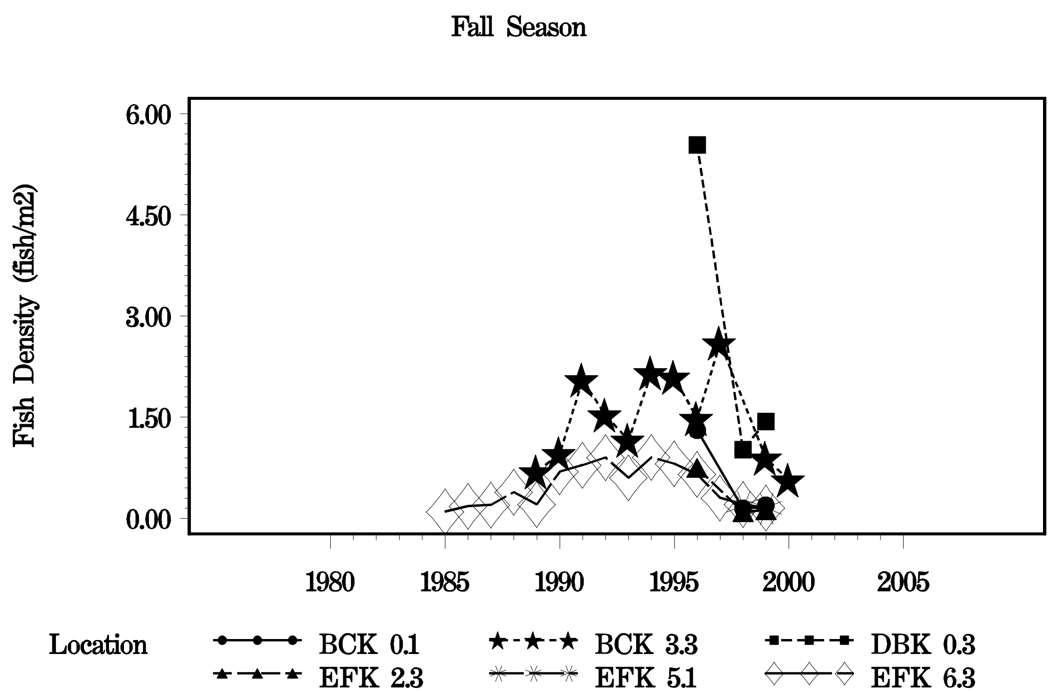

Figure 2. Fish density for the Fall sampling events.

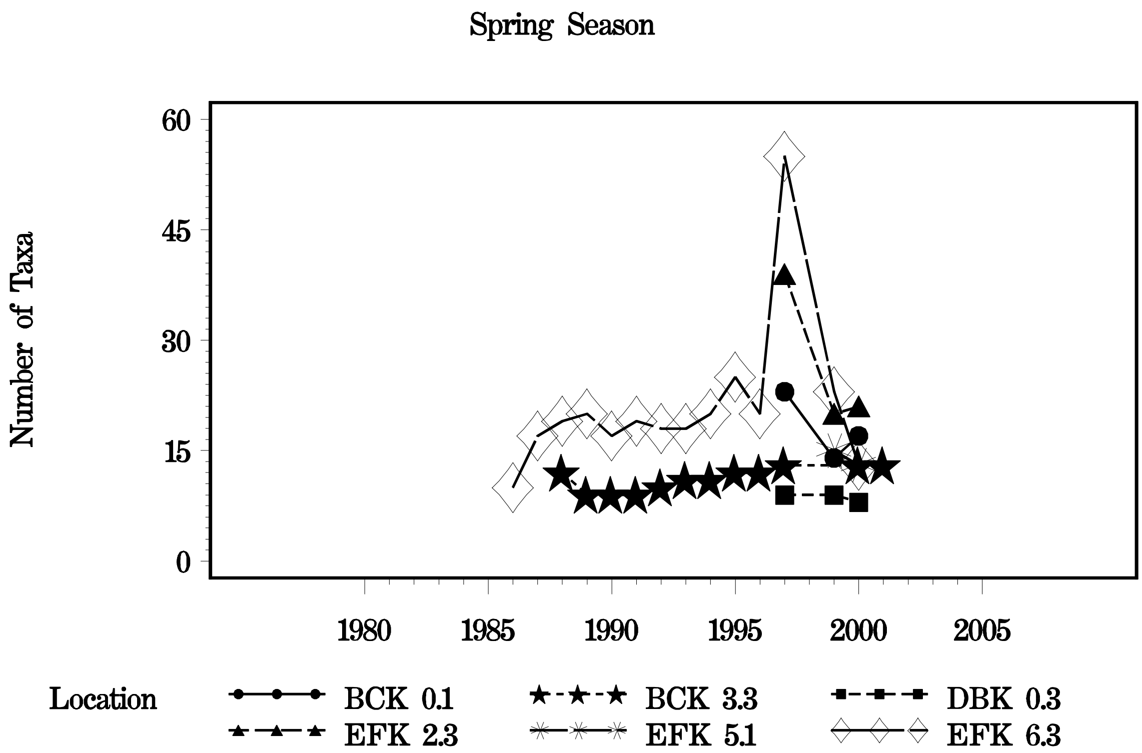

Figure 3. Number of taxa for the Spring sampling events.

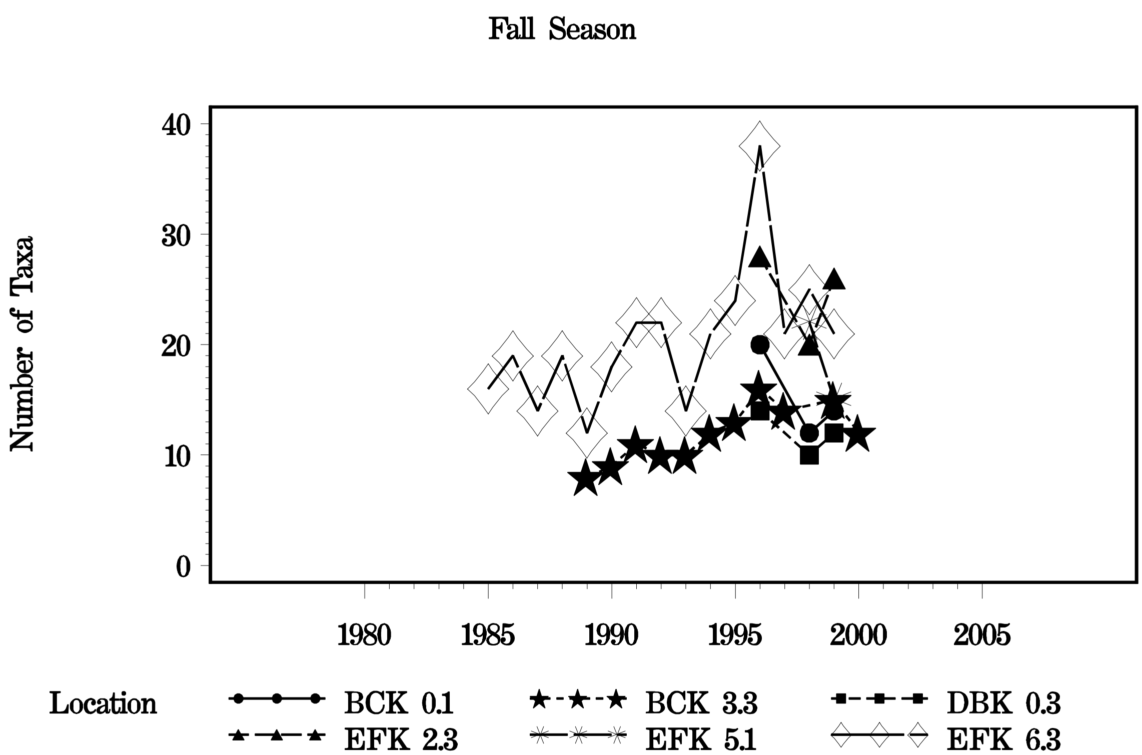

Figure 4. Number of taxa for the Fall sampling events.

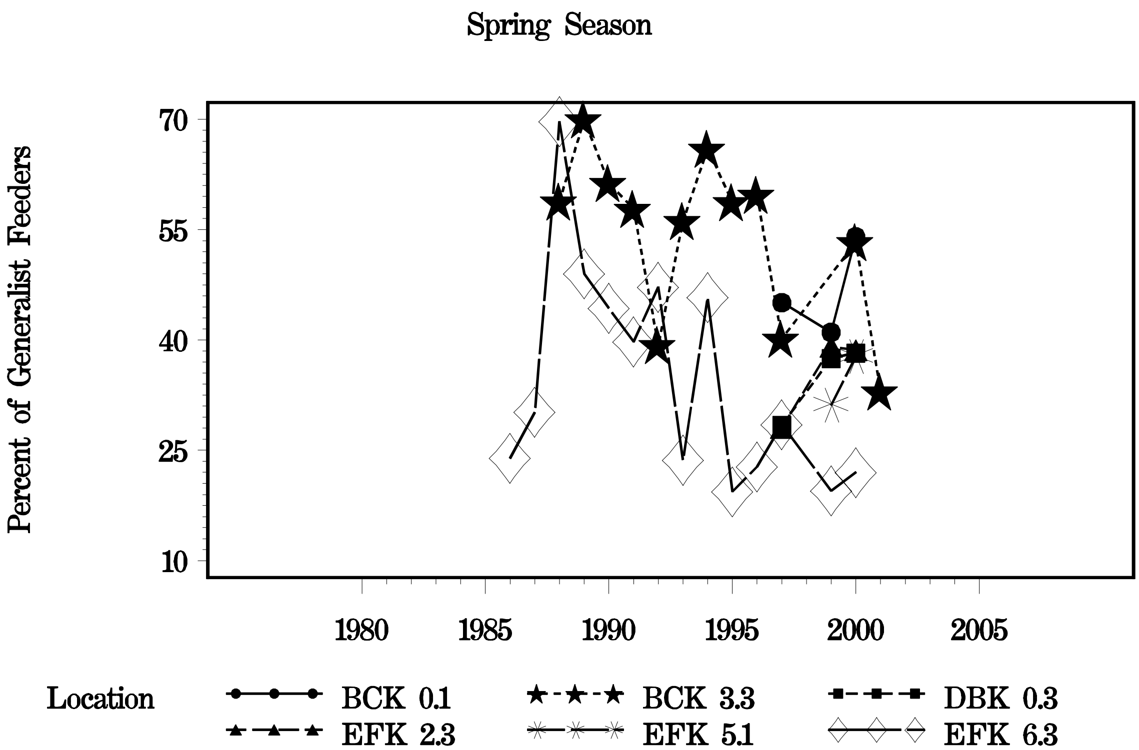

Figure 5. Percent generalist feeders for the Spring sampling events.

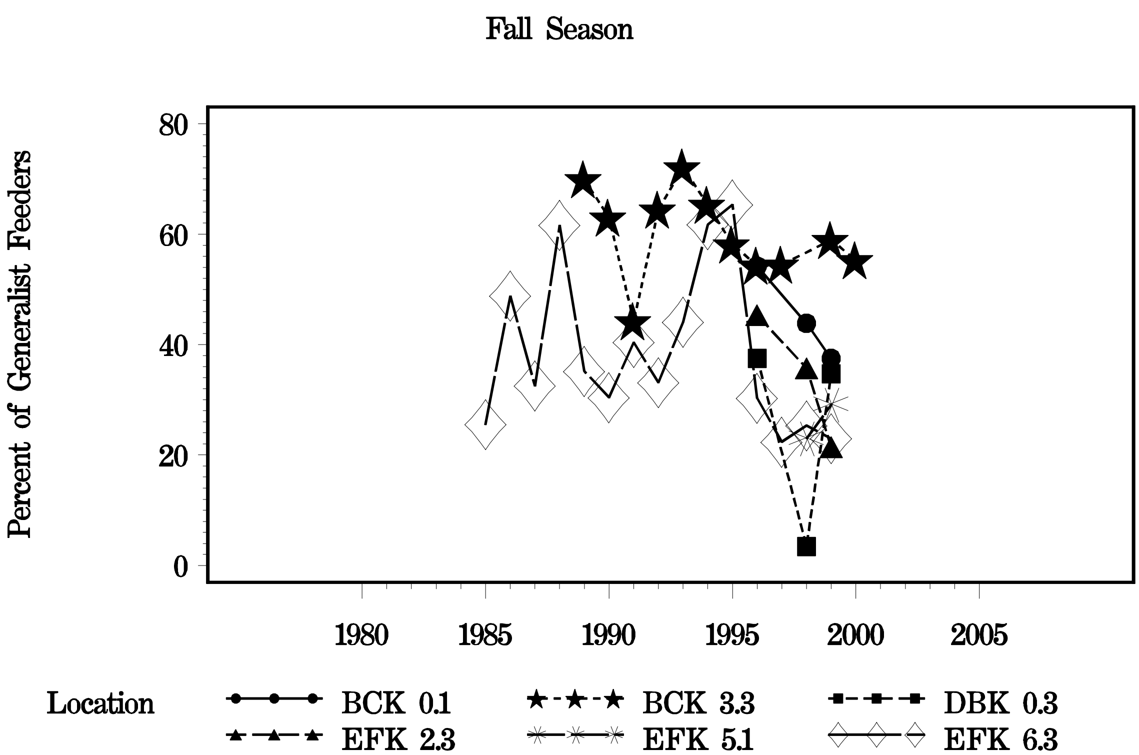

Figure 6. Percent generalist feeders for the Fall sampling events.

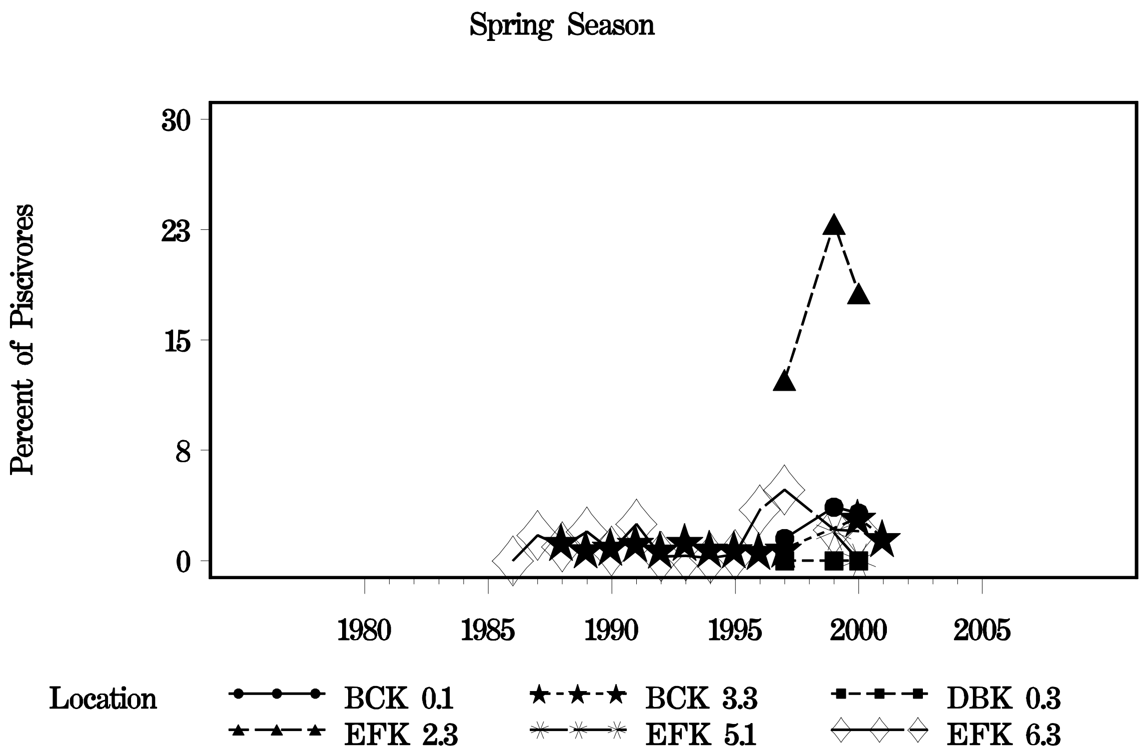

Figure 7. Percent piscivores for the Spring sampling events.

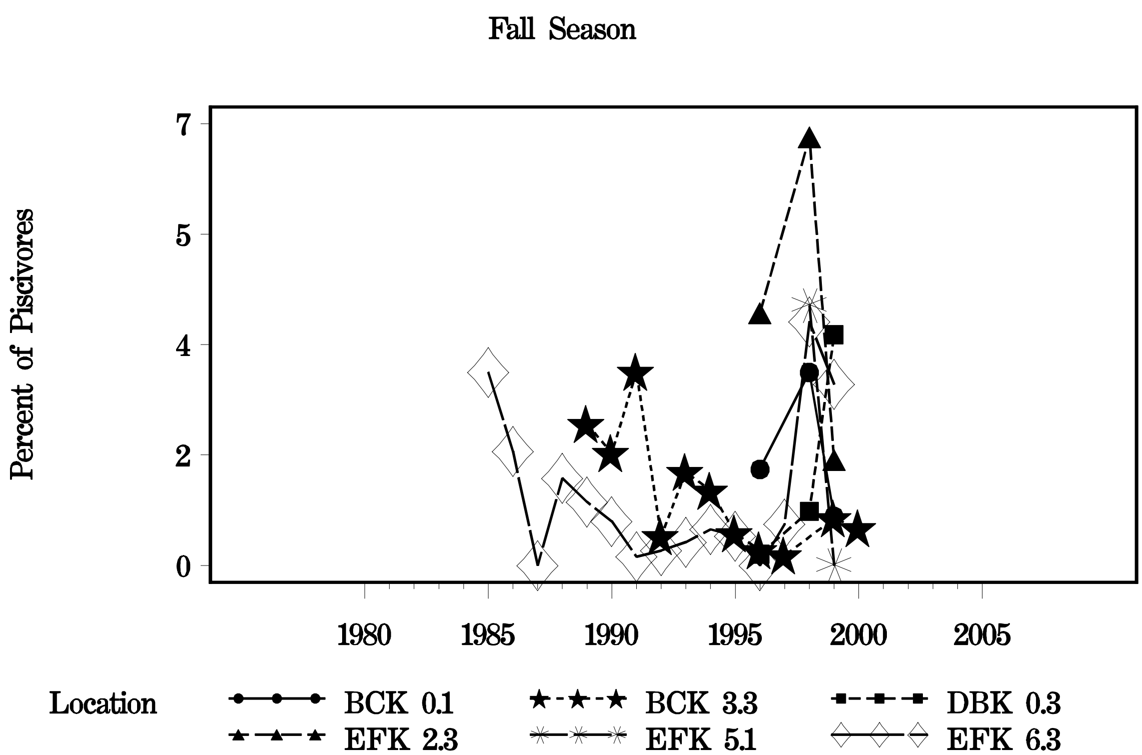

Figure 8. Percent piscivores for the Fall sampling events.

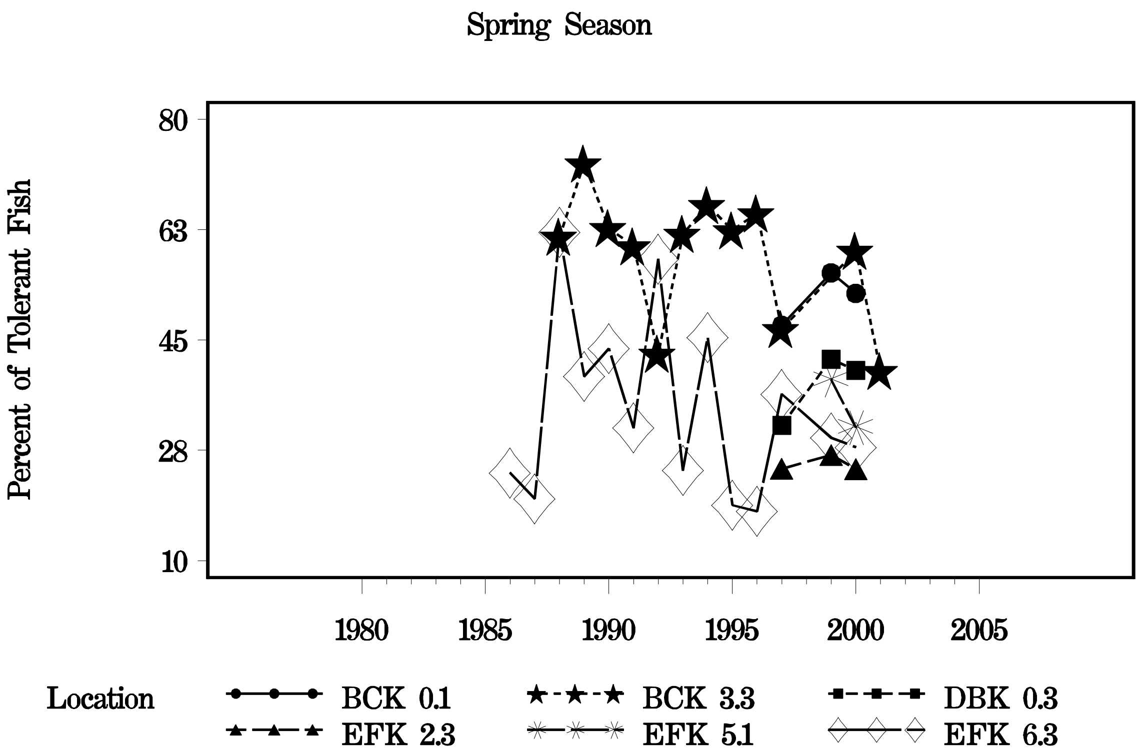

Figure 9. Percent tolerant fish for the Spring sampling events.

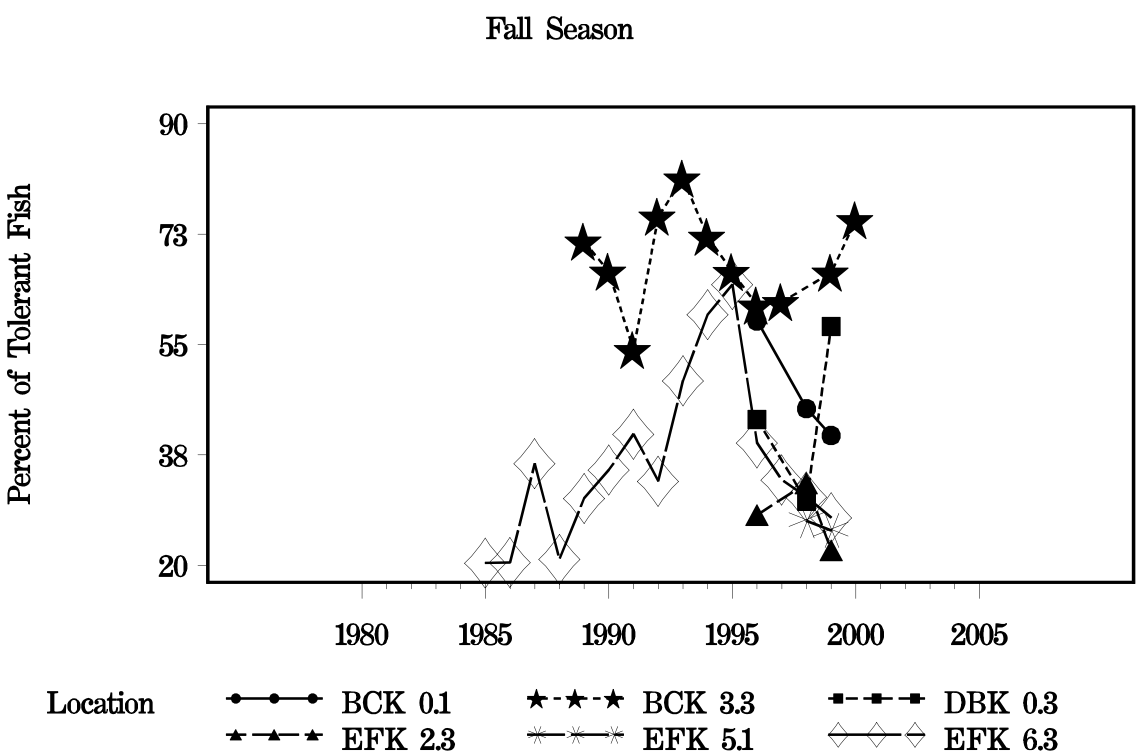

Figure 10. Percent tolerant fish for the Fall sampling events.

Table 1. Fish Data from ED-1 Locations Summarized by Sampling Event

Location	Year	Season	Fish Density (fish/m2)	Number of Taxa	Percent Generalist Feeders	Percent Piscivores	Percent Tolerant Fish
BCK 0.1	1996	Fall	1.31	20	54	2	59
BCK 0.1	1997	Spring	1.33	23	45	2	47
BCK 0.1	1998	Fall	0.15	12	44	3	45
BCK 0.1	1999	Spring	0.18	14	41	4	56
BCK 0.1	1999	Fall	0.20	14	38	1	41
BCK 0.1	2000	Spring	0.22	17	54	3	52
BCK 3.3	1988	Spring	1.59	12	59	1	61
BCK 3.3	1989	Spring	0.81	9	70	1	73
BCK 3.3	1989	Fall	0.69	8	70	2	71
BCK 3.3	1990	Spring	0.69	9	61	1	63
BCK 3.3	1990	Fall	0.96	9	63	2	67
BCK 3.3	1991	Spring	0.72	9	58	1	60
BCK 3.3	1991	Fall	2.05	11	44	3	54
BCK 3.3	1992	Spring	2.05	10	39	1	43
BCK 3.3	1992	Fall	1.53	10	64	0	75
BCK 3.3	1993	Spring	1.03	11	56	1	62
BCK 3.3	1993	Fall	1.16	10	72	1	81
BCK 3.3	1994	Spring	0.72	11	66	1	66
BCK 3.3	1994	Fall	2.16	12	65	1	72
BCK 3.3	1995	Spring	2.01	12	59	1	62
BCK 3.3	1995	Fall	2.09	13	58	1	66
BCK 3.3	1996	Spring	0.98	12	60	1	65
BCK 3.3	1996	Fall	1.48	16	54	0	61
BCK 3.3	1997	Spring	0.84	13	40	1	47
BCK 3.3	1997	Fall	2.60	14	54	0	62
BCK 3.3	1999	Fall	0.89	15	59	1	66
BCK 3.3	2000	Spring	0.46	13	53	3	59
BCK 3.3	2000	Fall	0.57	12	55	1	75
BCK 3.3	2001	Spring	0.66	13	33	2	40
DBK 0.3	1996	Fall	5.54	14	38	0	43
DBK 0.3	1997	Spring	3.94	9	28	0	31
DBK 0.3	1998	Fall	1.02	10	3	1	30
DBK 0.3	1999	Spring	0.84	9	38	0	42
DBK 0.3	1999	Fall	1.44	12	35	4	58
DBK 0.3	2000	Spring	0.68	8	38	0	40
EFK 2.3	1996	Fall	0.75	28	45	4	28
EFK 2.3	1997	Spring	0.57	39	28	12	25
EFK 2.3	1998	Fall	0.09	20	36	7	33
EFK 2.3	1999	Spring	0.11	20	39	23	27
EFK 2.3	1999	Fall	0.13	26	21	2	22
EFK 2.3	2000	Spring	0.14	21	39	18	25
EFK 5.1	1998	Fall	0.17	22	23	4	27
EFK 5.1	1999	Spring	0.11	15	31	2	39
EFK 5.1	1999	Fall	0.14	15	29	0	26
EFK 5.1	2000	Spring	0.12	13	38	0	31
EFK 6.3	1985	Fall	0.10	16	26	3	20
EFK 6.3	1986	Spring	0.05	10	24	0	24
EFK 6.3	1986	Fall	0.18	19	49	2	20
EFK 6.3	1987	Spring	0.11	17	30	2	20

Table 1. Fish Data from ED-1 Locations Summarized by Sampling Event (continued)

Location	Year	Season	Fish Density (fish/m2)	Number of Taxa	Percent Generalist Feeders	Percent Piscivores	Percent Tolerant Fish
EFK 6.3	1987	Fall	0.20	14	33	0	36
EFK 6.3	1988	Spring	0.22	19	70	1	62
EFK 6.3	1988	Fall	0.39	19	62	1	21
EFK 6.3	1989	Spring	0.23	20	49	2	39
EFK 6.3	1989	Fall	0.21	12	35	1	31
EFK 6.3	1990	Spring	0.15	17	44	1	44
EFK 6.3	1990	Fall	0.69	18	30	1	35
EFK 6.3	1991	Spring	0.18	19	40	2	31
EFK 6.3	1991	Fall	0.79	22	40	0	41
EFK 6.3	1992	Spring	0.29	18	47	0	58
EFK 6.3	1992	Fall	0.90	22	33	0	33
EFK 6.3	1993	Spring	0.30	18	24	0	24
EFK 6.3	1993	Fall	0.60	14	44	0	49
EFK 6.3	1994	Spring	0.49	20	46	0	45
EFK 6.3	1994	Fall	0.90	21	62	1	60
EFK 6.3	1995	Spring	0.65	25	19	0	19
EFK 6.3	1995	Fall	0.81	24	65	0	65
EFK 6.3	1996	Spring	0.15	20	23	3	18
EFK 6.3	1996	Fall	0.65	38	30	0	39
EFK 6.3	1997	Spring	0.74	55	29	5	36
EFK 6.3	1997	Fall	0.30	21	22	1	34
EFK 6.3	1998	Fall	0.21	25	25	4	31
EFK 6.3	1999	Spring	0.17	23	19	2	29
EFK 6.3	1999	Fall	0.16	21	23	3	28
EFK 6.3	2000	Spring	0.06	13	22	2	28

Table 2. Summary Statistics for Fish Density

Location	Season	Total Number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for Normality Test
BCK 0.1	Spring	3	0.57733	0.65219	112.967	1.33000	0.17937	0.77815
BCK 0.1	Fall	3	0.55150	0.65727	119.179	1.31000	0.14939	0.77950
BCK 3.3	Spring	12	1.04735	0.53754	51.324	2.05303	0.45667	0.81421
BCK 3.3	Fall	11	1.47093	0.67815	46.103	2.60246	0.56667	0.94060
DBK 0.3	Spring	3	1.82070	1.83715	100.904	3.94000	0.68000	0.78720
DBK 0.3	Fall	3	2.66538	2.49838	93.734	5.54000	1.01754	0.81917
EFK 2.3	Spring	3	0.27413	0.25653	93.579	0.57000	0.11369	0.79100
EFK 2.3	Fall	3	0.32259	0.37051	114.857	0.75000	0.09255	0.78716
EFK 5.1	Spring	2	0.11343	0.01051	9.267	0.12087	0.10600	1.00000
EFK 5.1	Fall	2	0.15550	0.02051	13.187	0.17000	0.14100	1.00000
EFK 6.3	Spring	14	0.27002	0.21143	78.302	0.73745	0.04742	0.84616
EFK 6.3	Fall	15	0.47349	0.29972	63.300	0.90486	0.09990	0.87135

Table 3. Regression Statistics for Fish Density

Location	Season	Total Number of Samples	Slope Estimate (Fish/m^2/y)	Standard Error	Pr > |t|	R^2	95% LCL on Slope	95% UCL on Slope
BCK 0.1	Spring	3	-0.39858	0.15306	0.2334	0.8715	-2.3433	1.5462
BCK 0.1	Fall	3	-0.40144	0.15490	0.2344	0.8704	-2.3697	1.5668
BCK 3.3	Spring	12	-0.04080	0.03885	0.3184	0.0993	-0.1274	0.04577
BCK 3.3	Fall	11	0.00093006	0.06278	0.9885	0.0000	-0.1411	0.1430
DBK 0.3	Spring	3	-1.15271	0.34315	0.1842	0.9186	-5.5129	3.2075
DBK 0.3	Fall	3	-1.49486	0.66369	0.2660	0.8353	-9.9279	6.9381
EFK 2.3	Spring	3	-0.15582	0.06265	0.2434	0.8609	-0.9518	0.6402
EFK 2.3	Fall	3	-0.22547	0.08942	0.2404	0.8641	-1.3617	0.9107
EFK 5.1	Spring	2	0.01487	.	.	1.0000	.	.
EFK 5.1	Fall	2	-0.02900	.	.	1.0000	.	.
EFK 6.3	Spring	14	0.01512	0.01312	0.2717	0.0996	-0.01347	0.04371
EFK 6.3	Fall	15	0.01490	0.01812	0.4258	0.0494	-0.02425	0.05405

Table 4. Summary Statistics for Number of Taxa

Season	Location	Total Number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for Normality
Spring	BCK 0.1	3	18.0000	4.5826	25.4588	23	14	0.96429
Fall	BCK 0.1	3	15.3333	4.1633	27.1522	20	12	0.92308
Spring	BCK 3.3	12	11.1667	1.5859	14.2023	13	9	0.86738
Fall	BCK 3.3	11	11.8182	2.5226	21.3453	16	8	0.97401
Spring	DBK 0.3	3	8.6667	0.5774	6.6617	9	8	0.75000
Fall	DBK 0.3	3	12.0000	2.0000	16.6667	14	10	1.00000
Spring	EFK 2.3	3	26.6667	10.6927	40.0975	39	20	0.78936
Fall	EFK 2.3	3	24.6667	4.1633	16.8784	28	20	0.92308
Spring	EFK 5.1	2	14.0000	1.4142	10.1015	15	13	1.00000
Fall	EFK 5.1	2	18.5000	4.9497	26.7554	22	15	1.00000
Spring	EFK 6.3	14	21.0000	10.4587	49.8034	55	10	0.63368
Fall	EFK 6.3	15	20.4000	6.1621	30.2064	38	12	0.86561

Table 5. Regression Statistics for Number of Taxa

Location	Season	Total Number of Samples	Slope Estimate (Taxa/y)	Standard Error	Pr > |t|	R^2	95% LCL on Slope	95% UCL on Slope
BCK 0.1	Spring	3	-2.35714	1.85577	0.4246	0.6173	-25.9369	21.2226
BCK 0.1	Fall	3	-2.28571	1.48461	0.3667	0.7033	-21.1495	16.5781
BCK 3.3	Spring	12	0.29174	0.07795	0.0038	0.5835	0.1181	0.4654
BCK 3.3	Fall	11	0.55049	0.14447	0.0042	0.6173	0.2237	0.8773
DBK 0.3	Spring	3	-0.28571	0.24744	0.4544	0.5714	-3.4297	2.8583
DBK 0.3	Fall	3	-0.85714	0.98974	0.5456	0.4286	-13.4330	11.7187
EFK 2.3	Spring	3	-6.50000	2.59808	0.2421	0.8622	-39.5117	26.5117
EFK 2.3	Fall	3	-1.14286	2.47436	0.7245	0.1758	-32.5826	30.2968
EFK 5.1	Spring	2	-2.00000	.	.	1.0000	.	.
EFK 5.1	Fall	2	-7.00000	.	.	1.0000	.	.
EFK 6.3	Spring	14	0.90832	0.63185	0.1761	0.1469	-0.4684	2.2850
EFK 6.3	Fall	15	0.77143	0.31665	0.0300	0.3134	0.08735	1.4555

Table 6. Summary Statistics for Percent of Generalist Feeders

Season	Location	Total Number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for Normality
Spring	BCK 0.1	3	46.7352	6.6363	14.1997	54.0323	41.0606	0.95517
Fall	BCK 0.1	3	45.1920	8.4265	18.6460	54.1985	37.5000	0.98175
Spring	BCK 3.3	12	54.5230	11.2650	20.6610	69.9620	32.9949	0.89643
Fall	BCK 3.3	11	60.0190	8.0065	13.3399	72.1068	44.2238	0.96740
Spring	DBK 0.3	3	34.7206	5.4633	15.7350	38.2353	28.4264	0.80588
Fall	DBK 0.3	3	25.2498	18.9321	74.9792	37.5451	3.4483	0.81090
Spring	EFK 2.3	3	35.2637	6.2338	17.6776	39.0845	28.0702	0.78046
Fall	EFK 2.3	3	34.1615	12.0428	35.2526	45.3333	21.4047	0.98701
Spring	EFK 5.1	2	34.4340	4.6696	13.5610	37.7358	31.1321	1.00000
Fall	EFK 5.1	2	26.0096	4.3394	16.6838	29.0780	22.9412	1.00000
Spring	EFK 6.3	14	34.6869	14.9115	42.9887	69.6682	19.3878	0.87511
Fall	EFK 6.3	15	38.6469	14.6026	37.7848	65.3442	22.3684	0.87881

Table 7. Regression Statistics for Percent of Generalist Feeders

Location	Season	Total Number of Samples	Slope Estimate (%/y)	Standard Error	Pr > |t|	R^2	95% LCL on Slope	95% UCL on Slope
BCK 0.1	Spring	3	2.25898	3.71096	0.6519	0.2704	-44.8933	49.4112
BCK 0.1	Fall	3	-5.50820	0.30115	0.0348	0.9970	-9.3347	-1.6817
BCK 3.3	Spring	12	-1.57010	0.69961	0.0487	0.3350	-3.1289	-0.01128
BCK 3.3	Fall	11	-0.76119	0.69646	0.3028	0.1172	-2.3367	0.8143
DBK 0.3	Spring	3	3.45066	0.94063	0.1694	0.9308	-8.5012	15.4025
DBK 0.3	Fall	3	-3.23235	11.96507	0.8320	0.0680	-155.26	148.80
EFK 2.3	Spring	3	3.80565	1.47356	0.2352	0.8696	-14.9177	22.5290
EFK 2.3	Fall	3	-7.52152	2.36266	0.1938	0.9102	-37.5419	22.4989
EFK 5.1	Spring	2	6.60377	.	.	1.0000	.	.
EFK 5.1	Fall	2	6.13684	.	.	1.0000	.	.
EFK 6.3	Spring	14	-1.74225	0.83567	0.0591	0.2659	-3.5630	0.07851
EFK 6.3	Fall	15	-0.63496	0.88833	0.4874	0.0378	-2.5541	1.2842

Table 8. Summary Statistics for Percent of Piscivores

Season	Location	Total Number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for Normality
Spring	BCK 0.1	3	2.7931	1.13658	40.692	3.6498	1.5038	0.89131
Fall	BCK 0.1	3	1.7897	1.16252	64.955	3.0612	0.7813	0.96161
Spring	BCK 3.3	12	1.1411	0.62270	54.570	2.9197	0.6711	0.70261
Fall	BCK 3.3	11	1.1328	0.92505	81.663	3.0686	0.1575	0.89891
Spring	DBK 0.3	3	0.0000	0.00000	.	0.0000	0.0000	.
Fall	DBK 0.3	3	1.5670	1.84307	117.615	3.6585	0.1805	0.89027
Spring	EFK 2.3	3	17.7833	5.31453	29.885	22.8873	12.2807	0.99578
Fall	EFK 2.3	3	4.1532	2.56098	61.663	6.7873	1.6722	0.99732
Spring	EFK 5.1	2	0.9434	1.33416	141.421	1.8868	0.0000	1.00000
Fall	EFK 5.1	2	2.0588	2.91162	141.421	4.1176	0.0000	1.00000
Spring	EFK 6.3	14	1.5300	1.40261	91.674	4.8105	0.0000	0.89307
Fall	EFK 6.3	15	1.1419	1.22034	106.866	3.8627	0.0000	0.83347

Table 9. Regression Statistics for Percent of Piscivores

Location	Season	Total Number of Samples	Slope Estimate (%/y)	Standard Error	Pr > |t|	R^2	95% LCL on Slope	95% UCL on Slope
BCK 0.1	Spring	3	0.64530	0.37043	0.3317	0.7522	-4.0614	5.3520
BCK 0.1	Fall	3	-0.10338	0.75399	0.9133	0.0185	-9.6838	9.4770
BCK 3.3	Spring	12	0.07096	0.04178	0.1203	0.2239	-0.02213	0.1640
BCK 3.3	Fall	11	-0.18118	0.06072	0.0154	0.4973	-0.3185	-0.04382
DBK 0.3	Spring	3	0	0	.	.	.	.
DBK 0.3	Fall	3	1.04241	0.60762	0.3360	0.7464	-6.6782	8.7630
EFK 2.3	Spring	3	2.44365	2.47654	0.5043	0.4933	-29.0238	33.9111
EFK 2.3	Fall	3	-0.46598	1.61050	0.8207	0.0772	-20.9293	19.9974
EFK 5.1	Spring	2	-1.88679	.	.	1.0000	.	.
EFK 5.1	Fall	2	-4.11765	.	.	1.0000	.	.
EFK 6.3	Spring	14	0.13735	0.08273	0.1228	0.1868	-0.04290	0.3176
EFK 6.3	Fall	15	0.02551	0.07535	0.7403	0.0087	-0.1373	0.1883

Table 10. Summary Statistics for Percent of Tolerant Fish

Season	Location	Total Number of Samples	Mean	Standard deviation	Coefficient of Variation	Maximum	Minimum	Probability for Normality
Spring	BCK 0.1	3	51.8159	4.1786	8.0643	55.6600	47.3684	0.98436
Fall	BCK 0.1	3	48.1005	9.4911	19.7318	58.7786	40.6250	0.91461
Spring	BCK 3.3	12	58.4497	9.9740	17.0643	73.0038	40.1015	0.87773
Fall	BCK 3.3	11	68.2926	7.6554	11.2096	81.3056	54.1516	0.97953
Spring	DBK 0.3	3	37.8775	5.6173	14.8301	41.9643	31.4721	0.87222
Fall	DBK 0.3	3	43.7467	13.8871	31.7444	57.9268	30.1724	0.99857
Spring	EFK 2.3	3	25.2891	1.2743	5.0390	26.7606	24.5455	0.75540
Fall	EFK 2.3	3	27.8132	5.3143	19.1070	33.0317	22.4080	0.99907
Spring	EFK 5.1	2	34.9057	5.3367	15.2888	38.6792	31.1321	1.00000
Fall	EFK 5.1	2	26.2954	1.0797	4.1060	27.0588	25.5319	1.00000
Spring	EFK 6.3	14	34.1291	14.0472	41.1591	62.0853	17.8218	0.91796
Fall	EFK 6.3	15	36.2034	13.1945	36.4454	64.5274	20.4082	0.90535

Table 11. Regression Statistics for Percent of Tolerant Fish

Location	Season	Slope Estimate (%/y)	Standard Error	Pr > |t|	R^2	95% LCL on Slope	95% UCL on Slope
BCK 0.1	Spring	2.03538	1.82766	0.4658	0.5536	-21.1873	25.2581
BCK 0.1	Fall	-6.17823	0.66000	0.0678	0.9887	-14.5644	2.2079
BCK 3.3	Spring	-1.19142	0.65955	0.1010	0.2460	-2.6610	0.2782
BCK 3.3	Fall	0.00603	0.70873	0.9934	0.0000	-1.5972	1.6093
DBK 0.3	Spring	3.24201	1.73559	0.3129	0.7772	-18.8108	25.2948
DBK 0.3	Fall	3.29827	8.47186	0.7636	0.1316	-104.35	110.94
EFK 2.3	Spring	0.15253	0.82017	0.8829	0.0334	-10.2688	10.5738
EFK 2.3	Fall	-1.23830	3.25118	0.7683	0.1267	-42.5485	40.0718
EFK 5.1	Spring	-7.54717	.	.	1.0000	.	.
EFK 5.1	Fall	-1.52691	.	.	1.0000	.	.
EFK 6.3	Spring	-0.70583	0.89594	0.4461	0.0492	-2.6579	1.2463
EFK 6.3	Fall	1.18877	0.74892	0.1365	0.1623	-0.4292	2.8067

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APPENDIX B
POWER ANALYSIS

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Power Analysis

The program TRENDS was used to calculate the power to detect a trend over the monitoring period. TRENDS was obtained at the following address on the web site of the Southwest Fisheries Science Center of the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration: http://swfsc.nmfs.noaa.gov/prd/software/Trends.html.

The power analysis in this program is based on a simple linear regression. The TRENDS program is summarized in 6 parameters: duration of study, sampling frequency, rate of change, measurement variability, alpha (type 1 error rate), and power (1-beta, where beta is the type 2 error rate). The TRENDS program estimates any one of the parameters if the other 5 are specified.

Power analysis tables were constructed using the TRENDS program. The tables report the statistical power for detecting a linear trend over a range of parameters that cover realistically expected ranges of sampling periods, sampling frequencies, alpha levels, rates of change, and measurement variability (coefficient of variation) at ED-1. The ranges chosen were: a 5-year (Tables 1 through 12) and 10-year sampling period (Tables 13 through 24); alpha levels of 0.05 (Tables 1 to 4 and 13-16), 0.10 (Tables 5 to 8 and 17-20), and 0.15 (Tables 9 to 12 and 21-24); and coefficients of variation of 20% (Tables 1, 5, 9, 13, 17, and 21), 40% (Tables 2, 6, 10, 14, 18, and 22), 60% (Tables 3, 7, 11, 15, 19, and 23), and 120% (Tables 4, 8, 12, 16, 20, and 24). The rows of each table show the power for a different sampling frequency from once-every-other-year to 4 samples per year. The columns of each table show a hypothetical rate of change per year from -20% to +5%.

To determine the power to detect a trend, find the variability of the measurement of interest by selecting the coefficient of variation (CV) from the summary statistics and select the monitoring period of interest. Then look at the power table for that CV and monitoring period. Look at Table 13 if the CV is 20% and the monitoring period 10 years. The table shows that if sampling is conducted once per year and the desired confidence is P = 0.95 (alpha = 0.05), the power to detect a decrease of 5% per year is 0.76. That means that there is a 76% chance that the trend would be detected.

These power analysis tables can be used prior to sampling to estimate the number of samples needed to achieve a desired power. They can be used after sampling to estimate the power achieved by the sampling effort given the actual CV of the data and the observed percentage difference of means.

References

http://swfsc.nmfs.noaa.gov/prd/software/Trends.html

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Gerrodette, T. 1991. Models for power of detecting trends – a reply to Link and Hatfield. Ecology 72: 1889-1892.

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Table 1. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.05 and 20% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.43	0.2	0.13	0.12	0.12	0.13
1 Sample/year	0.92	0.39	0.16	0.11	0.1	0.15
2 Samples/year	1	0.62	0.24	0.14	0.13	0.21
4 Samples/year	1	0.85	0.35	0.18	0.17	0.31

Table 2. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.05 and 40% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.23	0.13	0.11	0.11	0.11	0.11
1 Sample/year	0.47	0.17	0.1	0.08	0.08	0.09
2 Samples/year	0.73	0.25	0.12	0.09	0.08	0.11
4 Samples/year	0.93	0.38	0.16	0.1	0.1	0.14

Table 3. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.05 and 60% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.17	0.12	0.11	0.11	0.11	0.11
1 Sample/year	0.28	0.12	0.08	0.07	0.07	0.08
2 Samples/year	0.44	0.16	0.09	0.07	0.07	0.09
4 Samples/year	0.67	0.23	0.11	0.08	0.08	0.1

Table 4. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.05 and 120% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.12	0.11	0.11	0.11	0.11	0.11
1 Sample/year	0.14	0.08	0.07	0.06	0.06	0.07
2 Samples/year	0.19	0.09	0.07	0.06	0.06	0.07
4 Samples/year	0.27	0.12	0.08	0.06	0.06	0.07

Table 5. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.10 and 20% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.74	0.38	0.24	0.2	0.19	0.23
1 Sample/year	0.98	0.59	0.29	0.2	0.19	0.27
2 Samples/year	1	0.77	0.37	0.24	0.23	0.34
4 Samples/year	1	0.93	0.5	0.3	0.29	0.46

Table 6. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.1 and 40% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.43	0.24	0.19	0.18	0.18	0.19
1 Sample/year	0.68	0.3	0.18	0.15	0.14	0.17
2 Samples/year	0.86	0.4	0.21	0.16	0.16	0.2
4 Samples/year	0.97	0.54	0.26	0.18	0.18	0.24

Table 7. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.1 and 60% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.32	0.21	0.18	0.17	0.17	0.18
1 Sample/year	0.46	0.22	0.15	0.13	0.13	0.15
2 Samples/year	0.61	0.27	0.17	0.14	0.14	0.16
4 Samples/year	0.8	0.36	0.2	0.15	0.15	0.19

Table 8. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.1 and 120% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.22	0.18	0.17	0.17	0.17	0.17
1 Sample/year	0.25	0.16	0.13	0.12	0.12	0.13
2 Samples/year	0.31	0.17	0.13	0.12	0.12	0.13
4 Samples/year	0.41	0.21	0.14	0.12	0.12	0.14

Table 9. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.15 and 20% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.9	0.54	0.34	0.28	0.27	0.32
1 Sample/year	1	0.71	0.39	0.28	0.27	0.36
2 Samples/year	1	0.85	0.48	0.32	0.31	0.44
4 Samples/year	1	0.96	0.61	0.39	0.38	0.56

Table 10. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.15 and 40% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.6	0.35	0.26	0.24	0.24	0.26
1 Sample/year	0.79	0.41	0.26	0.21	0.21	0.25
2 Samples/year	0.91	0.5	0.29	0.23	0.22	0.28
4 Samples/year	0.98	0.64	0.35	0.26	0.25	0.33

Table 11. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.15 and 60% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.45	0.29	0.24	0.23	0.23	0.24
1 Sample/year	0.58	0.31	0.22	0.19	0.19	0.21
2 Samples/year	0.71	0.37	0.24	0.2	0.2	0.23
4 Samples/year	0.86	0.46	0.27	0.22	0.21	0.26

Table 12. Power to Detect Change Using Linear Regression Over a 5-Year Sampling Period at an Alpha Level of 0.15 and 120% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.31	0.25	0.23	0.22	0.22	0.23
1 Sample/year	0.34	0.23	0.19	0.17	0.17	0.18
2 Samples/year	0.41	0.25	0.19	0.17	0.17	0.19
4 Samples/year	0.51	0.28	0.21	0.18	0.18	0.2

Table 13. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.05 and 20% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	1	0.92	0.39	0.2	0.18	0.3
1 Sample/year	1	1	0.76	0.38	0.32	0.59
2 Samples/year	1	1	0.95	0.58	0.49	0.83
4 Samples/year	1	1	1	0.82	0.72	0.97

Table 14. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.05 and 40% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.96	0.47	0.17	0.11	0.1	0.14
1 Sample/year	1	0.87	0.32	0.17	0.15	0.24
2 Samples/year	1	0.99	0.49	0.24	0.2	0.36
4 Samples/year	1	1	0.73	0.36	0.3	0.56

Table 15. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.05 and 60% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.75	0.28	0.12	0.09	0.08	0.11
1 Sample/year	1	0.59	0.2	0.12	0.11	0.15
2 Samples/year	1	0.82	0.29	0.15	0.13	0.22
4 Samples/year	1	0.97	0.45	0.22	0.18	0.33

Table 16. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.05 and 120% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.33	0.14	0.08	0.07	0.07	0.08
1 Sample/year	0.81	0.24	0.11	0.08	0.07	0.09
2 Samples/year	0.97	0.36	0.14	0.09	0.08	0.11
4 Samples/year	1	0.56	0.19	0.11	0.1	0.15

Table 17. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.1 and 20% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	1	0.98	0.59	0.34	0.31	0.48
1 Sample/year	1	1	0.88	0.54	0.47	0.75
2 Samples/year	1	1	0.98	0.72	0.64	0.91
4 Samples/year	1	1	1	0.9	0.84	1

Table 18. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.1 and 40% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	1	0.6	0.3	0.2	0.19	0.26
1 Sample/year	1	0.98	0.48	0.28	0.25	0.38
2 Samples/year	1	1	0.65	0.37	0.32	0.51
4 Samples/year	1	1	0.84	0.5	0.44	0.7

Table 19. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.1 and 60% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.9	0.46	0.22	0.17	0.16	0.2
1 Sample/year	1	0.74	0.32	0.21	0.19	0.26
2 Samples/year	1	0.91	0.43	0.26	0.23	0.34
4 Samples/year	1	0.99	0.59	0.34	0.3	0.47

Table 20. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.1 and 120% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.51	0.25	0.16	0.13	0.13	0.15
1 Sample/year	0.7	0.31	0.17	0.14	0.13	0.16
2 Samples/year	0.88	0.41	0.21	0.15	0.15	0.18
4 Samples/year	0.98	0.57	0.26	0.18	0.17	0.22

Table 21. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.15 and 20% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	1	1	0.71	0.45	0.41	0.61
1 Sample/year	1	1	0.93	0.65	0.58	0.83
2 Samples/year	1	1	0.99	0.8	0.73	0.95
4 Samples/year	1	1	1	0.94	0.89	1

Table 22. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.15 and 40%a CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	1	0.79	0.41	0.29	0.27	0.35
1 Sample/year	1	0.97	0.58	0.37	0.34	0.48
2 Samples/year	1	1	0.74	0.46	0.42	0.61
4 Samples/year	1	1	0.89	0.6	0.54	0.78

Table 23. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.15 and 60% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.96	0.58	0.31	0.24	0.23	0.28
1 Sample/year	1	0.82	0.42	0.29	0.27	0.35
2 Samples/year	1	0.95	0.53	0.34	0.31	0.44
4 Samples/year	1	1	0.69	0.43	0.39	0.57

Table 24. Power to Detect Change Using Linear Regression Over a 10-Year Sampling Period at an Alpha Level of 0.15 and 120% CV.

	Change Per Year					
Sampling Frequency	**-20%**	**-10%**	**-5%**	**-3%**	**+3%**	**+5%**
1 Sample every other year	0.64	0.34	0.23	0.19	0.19	0.21
1 Sample/year	0.79	0.41	0.25	0.2	0.2	0.23
2 Samples/year	0.93	0.51	0.28	0.22	0.21	0.25
4 Samples/year	1	0.66	0.34	0.25	0.24	0.3

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